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*HINDENBURG.

By COL. B. R. WARD, C.M.G.

ALTHOUGH this book bears the name of Hindenburg alone on the title-page, some fifty pages at the end of the work are devoted to a study of Ludendorff and to a comparison of the two great German leaders.

The portion of the book devoted to Hindenburg describes first his career, then his principal characteristics, his principles of war, and lastly his peculiarities.

The latter portion of the book is entitled " Hindenburg and Ludendorff," and contains first a description of the personality and characteristics of Ludendorff, next a comparison of the two men, pointing out their similarities and points of difference. This is followed by an essay as to the part played by each one in the conduct of the war, and a general conclusion as to the real nature of the two men.

In the Preface General Buat refers to a recent work of his on Ludendorff based on his written *My War Memories*, and expresses entire confidence that he will pursue his dream and that we shall see him in the future, in fact if not in appearance, playing a leading part among the numerous Pangermanists who are determined to act their play " Deutschland Uber Alles," which he freely translates " Germany at the head of the nations."

The publication of Hindenburg's *Life* has given our author an opportunity of making a study of the chief of a similar character to the one he has already made of his Chief Staff Officer.

A quotation from the writings of the famous naturalist Buffon occurs both in the Preface and at the close of the last chapter of the book.

The first quotation : " *Le style est l'homme même*," emphasizes the possibility of detecting the true nature of both Hindenburg and Ludendorff from their written memoirs. The last quotation is to the effect that " for every species there exists in nature a general prototype on which each individual of the species is modelled." This quotation is made use of to indicate that whereas Ludendorff reveals himself in his book as the Prussian prototype, full of pride if not of vanity, ambitious without any scruple, a conqueror without pity and even boasting of his inhumanity, spiteful without magnani-

* By General Buat. Librairie Chapelot, 136, Boulevard Saint-Germain, Paris. 1921.

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mity, passionate almost to the point of insanity, rough in manner as in thought, Hindenburg on the other hand, though conforming no less to the Prussian prototype, represents a very different variety of the species. He is lacking in pride, is without ambition and without hate, a little inclined to be ashamed of the cruelties with which his armies are reproached, a moderate Pangermanist, by nature tolerant, kindly in his judgments, good-natured and easy of approach, while at the same time the slave of duty. In other words, the self-revelation of Hindenburg as effected by his book exhibits a far more sympathetic figure than that of his too-pushing Chief of Staff, who in spite of his undoubted military talents has succeeded in alienating all natural sympathy by means of his self-portraiture in his *Memories*.

It will be seen from the foregoing that General Buat's book is in its essence a psychological study, devoted in the main to Hindenburg, but at the same time comparing and contrasting him with his Chief of Staff. The fact that the book begins and ends with quotations from a writer on natural history emphasizes the scientific nature of General Buat's work. The question is not so much what Hindenburg has done as what his essential qualities are, how he should be classified as an individual specimen of humanity.

In the first place our author lays stress on the fact that he comes of an old Prussian family in which military service is a tradition even more than a duty. He was born at Posen—now in the Polish area—in 1847, and in becoming a cadet at the age of ten he did no more than accomplish the natural act for which he was destined. In 1866, as a Second Lieutenant in the 3rd Regiment of Infantry of the Prussian Guard, he distinguished himself at Rosberitz where he was wounded in the head. In 1870 he was at Saint-Privat, Sedan, and Paris,and was present at the proclamation at Versailles of the German Empire on the 18th January, 1871.

From 1873 to 1876 he was a student at the War Academy, and from 1876 to 1878 he served on the Great General Staff at Headquarters. In 1880 he served at Königsberg as a Captain on the staff of General Verdy du Vernois, an eminent chief, a distinguished military writer, and an educator of the first rank. In 1884, at the age of 37, after a period of fifteen months in command of a Company of the 58th Regiment—a regiment recruited in Polish Prussia—he was appointed to the Operations Branch of the Great General Staff, then under the direction of von Schlieffen. Here he assisted in drawing up a new edition of the Field Service Regulations, and followed this up by five years as an Instructor in Tactics at the War Academy. In 1890 he became Director of a Branch of the War Ministry, under his old chief Verdy du Vernois, at that time Minister of War. Here he drew up the Regulations for Pioneers on service, and for the employment of heavy artillery in the field.

At the age of 46, in 1893, he was promoted to the rank of Colonel, and was in command of the 91st Regiment of Infantry till 1896,

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when he was gazetted Brigadier-General and became Chief of Staff of the 8th Corps at Coblentz.

In 1900, at the age of 53, he was given command of the 28th (Baden) Division. In January, 1903, at the age of 56, he was placed in command of the 4th Corps at Magdeburg. For nearly eight years he held this important command, until in 1910, at the age of 64, desirous of giving way, as he tells us, to younger men, and despairing of ever seeing active service again, he applied to be placed on the retired list. His application was granted, and for nearly four years he remained on the retired list. On the 22nd August, 1914, he was already beginning to fear that his sovereign had forgotten him when a telegram arrived from General Headquarters asking him if he was ready to accept a new post. In spite of his 68 years he replied laconically: "Am ready." Half an hour later a dispatch from General Ludendorff informs the retired General that he has been provided with a Chief of Staff, and that on the following day—23rd August—between three and four o'clock in the morning he will arrive at Hanover Station by special train destined to conduct them both to their destination. At about half-past seven that evening a second Imperial telegram informs Hindenburg that he is to command the 8th Army in East Prussia. The next morning early Hindenburg is at the station. The special, containing two coaches and some baggage trucks, steams in. An officer wearing the cross he has just gained for bravery at Liège steps on to the platform. This is the first meeting of the two men who are destined for the next four years to act in such close co-operation that to the world at large the two names Hindenburg and Ludendorff seem almost to represent one individual.

The most successful military operation connected with the names of the two men occurred within a week of their first meeting. The Battle of Tannenberg took place on the 27th to 29th August, 1914, and this was followed by the first Battle of the Mazurian Lakes on the 7th and 8th September. Within three weeks of their meeting at Hanover, East Prussia had been cleared of the Russian invaders, Hindenburg had been made Colonel-General and decorated with the first grade of the Iron Cross.

It is impossible to follow in detail their combined career except to mark the dates of outstanding events in their military history.

On the 29th August, 1916, Hindenburg was appointed Commander-in-Chief of the German Armies with Ludendorff as his Chief of Staff —First Quartermaster General. Roumania had just declared war, and the general situation was looking decidedly gloomy for the Central Powers.

The first task which confronted the new Chief was to assure unity of command among the four allied armies—German, Austrian, Bulgarian, and Turkish. The next was to carry out new schemes of

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recruiting, organization, instruction, and other internal reforms. The third was to tackle the awkward military situation created by Roumania's entry into the war. In France the Battle of the Somme was in full swing after the failure of the German attack at Verdun which commenced in February, 1916. By the end of the year Roumania had been completely overrun by Mackensen's forces, and the German line had managed to hold on in France. This allowed breathing space to consider their plans for 1917.

Early in this year, acting on a report from the German Admiralty that England would be forced in a few months to sue for peace, Hindenburg and his Chief of Staff declared in favour of unrestricted submarine warfare. As a result America joined the Entente, but on the other hand the Russian Revolution paved the way for a settlement of affairs in the East, and allowed of a transfer of German Divisions to the Western Front for the " Kaiser Battle " of 1918.

The failure of this great offensive led to Ludendorff's resignation on the 26th October. Hindenburg still remained in command, and after the signature of the terms of the Armistice by the German delegates on the 11th November, Hindenburg, under the Kaiser's orders, carried out the terms and conducted the armies to the right bank of the Rhine. Having fully completed his task he went back quietly to retirement in Hanover, whence he had emerged so confidently on the 23rd August, 1914. The mere enumeration of the duties and responsibilities carried out by Hindenburg during those four years is sufficient to show that the old man—he was now over 71 years of age—was the possessor of an iron frame.

A powerful physical frame does not always accompany perfect health and vitality, but Hindenburg is reported to be able to sleep at any hour, no matter what mental strain he may have been subjected to beforehand. Nor is he over particular as to where he sleeps. A bed, sofa, or chair are all equally serviceable for him to sleep on. A clear indication, as General Buat puts it, of a tranquil disposition and an absence of nerves ! This tranquility, however, is not an indication of sluggishness. He is naturally gay, is fond of youth, and never stands on his dignity. Here is one of his inspection reports on a regiment : " Discipline excellent, but the subalterns are too solemn."

At General Headquarters he keeps up the tradition of jokes and merriment which he used to encourage at the cadet school. He looks upon it " as a duty " to keep his collaborators cheerful and in good spirits.

With all this *bonhomie* and good nature it must not be imagined that Hindenburg is in any way lacking in firmness of character. As we shall see later in discussing his principles of war there is nothing he lays more stress upon than an indomitable will. From his childhood, he tells us, his parents set themselves to develop him into a

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man possessing a powerful personality in a vigorous frame. If the personality of Ludendorff is overwhelming in its aggressive egotism, the more modest personality of Hindenburg overflows with life and good spirits. The motive power at the back of this vigorous personality may be described in three words. He is an aristocrat. He is a Prussian. He is an ultra-monarchist.

His full surname is " von Beneckendorff und von Hindenburg," and he is immensely proud of being a von Beneckendorff, a family that can trace its descent back to the year 1280. He is an intensely patriotic German, but Prussia is the surest and firmest support of the Empire, and in the reigning family Prussia finds her living expression. He always alludes to his sovereigns in semi-religious terms.

In 1859, when he was a cadet of 12, Prince Frederick William, the future Emperor Frederick, and his wife visited the school, and Hindenburg for the first time saw members of the Royal family at close quarters; never before did he " kick his legs so high at the march-past, or perform such perilous gymnastic exercises."

When in 1867, on his return from the Austrian campaign, King William at an inspection of his regiment inquired of him the circumstances under which he had gained the cross of the Red Eagle with swords, he felt thrilled with a sacred emotion.

On the 18th January, 1871, he was present at Versailles at the proclamation of the German Empire. His heart was thrilled with joy, but what moved him most, " as may be well imagined," was the apotheosis of his " august King and Lord."

A little later, the old Emperor appeared one day at the window of his palace in Berlin in response to the cheers of the people outside. Hindenburg, who was in the crowd with one of his sons, a boy of five, raised the child in his arms and said: " Never forget this moment, and you will always do your duty."

He never fails, at the slightest opportunity, to extol the qualities and the character of his Emperor. Can anyone say that William II. is anything but a man of simple tastes and careless of personal comfort considering that at Avesnes, during the spring offensive of 1918 he lived for several weeks in a train? Can his courage be doubted in view of the fact that he took no notice of the dangers he was incurring from hostile aviators?

Even the Crown Prince comes in for his praises. He is chivalrous, energetic, frank in manner, and his military judgment is sound. Finally when as a result of the treaty of Versailles, popular clamour demands that William II. shall be given up to the Allies in order that he may be brought to trial for the crimes for which he is nominally responsible, Hindenburg offers to take his place as the prisoner at the bar.

An aristocratic, Prussian, and monarchical tradition is thus seen

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to be the driving force behind all his actions. What are the principles of war on which he lays most stress? In the first place strength of will, firmness of mind and character are in his opinion more valuable to a soldier than any refinement of intellect. Energy in action, the result of a decision once arrived at, is far more important than intellectual subtleties.

Calmness on critical occasions—a calmness which according to General Buat only failed him on two occasions, first after his defeat on the 8th August, 1918, and more especially after the Bulgarian collapse in the following month—is another quality on which he lays great stress.

Firmness of character implies a love of responsibility, but this does not mean the denial of responsibility to subordinates. As a Colonel he always endeavoured to give to his juniors "the right and the duty of acting with independence and initiative." This method of dealing with subordinates illustrates a striking characteristic, which Hindenburg displays in all his dealing with and comments on other people. He is eminently reasonable in his judgments and is very slow to condemn decisions honestly arrived at, merely because they did not eventuate in success.

Thus he even finds excuses for the politicians who were unable to prevent Roumania from declaring herself on the side of the Entente. "It is all very well for people who know nothing of the facts to judge them severely. People who criticize like that, generally base their criticisms on unsupported affirmations, and are like those writers ridiculed by Fichte in his *Message to the German Nation* who can never say what ought to be done until after the event has happened."

The Army Order issued by Hindenburg on the 12th November, 1918, illustrates this characteristic. While full of personal dignity, it makes full acknowledgment of the efforts put forth by the troops, the Government, and the Allies of Germany, in order to stave off the recent catastrophe.

For Hindenburg's intellectual qualities General Buat expresses respect but no particular enthusiasm, and if on the whole he finds much which Frenchmen can sympathise with in the character of the old Field Marshal he none the less points out the real weak spot of the Prussian tradition. Prussian loyalty and *esprit de corps* flourish especially amongst the corps of officers and Hindenburg defines this feeling as "a personal link uniting each officer to his King, as the vassal to his suzerain." "It is the same sentiment," says General Buat, "which animates the old monarchical and conservative families of Prussia. They have no understanding whatever of Humanity and can conceive of no system of order but a particularistic one based on the power of a State, solidly centralized and administered, the whole resting upon an army sufficiently powerful to conquer or to retain under all circumstances the place due to their country in the world."

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THE ACTIVATED SLUDGE PROCESS OF SEWAGE PURIFICATION.

By CAPTAIN C. C. ADAMS, M.C., R.E.

IN the design of modern plants for sewage disposal, there has been a great tendency for engineers to break away from the anaerobic, or septic tank treatment, in favour of aerobic methods. Many systems for aerobic treatment have been devised during the last thirty years, the most modern being the activated sludge process, which has good claims to be considered the most satisfactory yet discovered.

The main objections to the septic tank system are due to the harmful and objectionable gases which are given off during the decomposition of the sewage, which prohibit the treatment being carried out in the neighbourhood of buildings. Further, the sludge produced by anaerobic action in the tank is of an offensive nature.

Many years ago, it was found that contact beds of clinker, designed to oxidize the septic tank effluent, are capable of treating raw sewage, provided the filling is of reasonably large material, in order to prevent clogging. After primary treatment in these "roughing beds," the effluent is given a further treatment in beds composed of smaller diameter filling, and so becomes completely stable and harmless. This system does not cater for any action by the anaerobic bacteria, and the objections to the septic tank are eliminated. Some solid matter or "humus" is carried off in the final effluent and a similar material is formed in the beds themselves, and in time chokes them up. This "humus" bears little resemblance to septic tank sludge; it is black, granular, easily dried, quite inoffensive and with a smell similar to that of vegetable mould. It is found to contain large numbers of aerobic bacteria.

After a contact bed has been emptied of sewage, it is necessary for it to rest empty for some hours, in order that interstices between the lumps of clinker may become filled with fresh air. This aeration is most important, and is essential for the efficient working of the bed, for without it, the aerobic bacteria cannot carry out their oxidizing action. It is found that a bed gives better results after it has been in use for some little time, the reason being that the "humus" which collects in the interstices contains, as has been stated above, aerobic bacteria in large numbers, and is, in fact, a bacterial culture.

A process which is identical in action takes place in Dibden's biological beds, the difference being that in these, the clinker is replaced by layers of slates or tiles.

For the efficient oxidization of sewage by this method it will be

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seen that three essentials are necessary, the sewage, air, and an aerobic bacterial culture, and the more intimate the contact between these three, the more rapidly will the oxidization take place, and the more efficient will be the system.

In contact beds a high efficiency is not possible, owing to the fact that the "humus" forms in large lumps, and the area of contact between the sewage and the air is a comparatively small one.

The Activated Sludge process works on identical principles, but in this case a much higher efficiency is aimed at, and obtained, by intimately mixing the sewage with the bacterial culture by agitation. At the same time, minute bubbles of air are blown through the mixture, and a practically infinite surface of contact is thus produced.

A forced aeration process was tried early in 1912 at the Lawrence Experimental Station of the State Department of Health of Massachusetts. At the end of that year the work was shown to Dr. Gilbert Fowler, of Manchester, and with the aid of his colleagues, Dr. Ardern and Mr. Lockett, the process was brought to its present state of perfection.

The main action takes place in aerating tanks, in the bottom of which are "diffusers" of a special porous material, through which compressed air is passed and atomized, so that it rises in minute bubbles through the sewage. This aeration is continued until chemical tests show that all the ammonia in the sewage has been oxidized into nitrates. If the air is then turned off, the sludge will rapidly sink to the bottom, and the liquid can be decanted. This sludge is "activated sludge" and will be found essentially different to septic tank sludge, in that it is inoffensive and is an aerobic bacterial culture; in appearance, however, it resembles septic tank sludge rather than the "humus" from filter beds. If this sludge is left in the tank, and the latter is again filled up with sewage and the aeration continued, the nitrification of the second filling will take place rather more rapidly, owing to the presence of this "bacterial culture." This process can be repeated, and at each filling the oxidization will take place more rapidly, until when the tanks are about one-quarter full of activated sludge, complete nitrification occurs in a few hours. The plant is then ready for work. Actually it takes some weeks to build up the necessary quantity of activated sludge for the purification to take place in a minimum time. It is found that about 10 per cent. activated sludge can be obtained in 10–20 days; this is aerated continuously for a week, and the plant will then be in a fit state to work, but it will continue to improve in efficiency until it has been in action about three months. The tanks will then contain about 25 per cent. activated sludge. This period of building up can be reduced considerably if some previously activated sludge, or contact bed "humus" can be obtained from another plant.

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It should be mentioned that the purification of the sewage appears to take place in two stages. The first is a rapid carbon oxidization process, in which the organic matter is broken down, and the carbon is converted into carbon dioxide. After this action, the liquid is found to be stable, but it is generally desirable to continue the aeration for a time, in order to allow the second oxidization to take place. In this, nitrates are formed in the liquid, and one can then be certain that the effluent will be highly purified and absolutely non-putrescible.

About 42 tons of wet sludge are obtained from one million gallons of sewage. It resembles septic tank sludge in appearance, but is very different in its properties. It contains large numbers of bacteria, as many as 22 millions having been found in 1 c.c., in addition to bacterial flora and protozoa. It is dark brown in colour with an earthy odour and contains 97-99 per cent. water; even after prolonged standing under water, this figure is only reduced to about 96 per cent. Up to the present time, no thoroughly satisfactory means of drying the sludge for commercial use has been found, as it is extremely flocculent, and microscopical examination shows it to be composed of immense numbers of minute "sausage skins" which contain water, and are not easily broken up. By lagooning and air drying, preferably on ash beds, the moisture content is reduced to 75-85 per cent. in about four days, and the sludge has then lost its colloidal nature, is granular in appearance, odourless and is spadeable. The moisture content can be still further reduced by pressing, and by heating it can be got as low as 10 per cent.; the sludge then appears to be quite dry and still retains its manurial value, although the latter is reduced if a high temperature has been used.

It is found that activated sludge will keep inoffensive under water for an indefinite time, provided it is aerated occasionally, but a process of auto-digestion sets in, and this has the effect of reducing the bacteria and quantity of organic matter present. It is extremely important that no particle of the sludge should be allowed to stagnate and become free from air. If this happens it will go black, become septic, and foul the effluent.

It will be seen from the following table, which gives the composition of the sludge, that it has a large nitrogen content, so that its value as a fertilizer is extremely high; it contains, in fact, three to four times as much nitrogen as the average septic tank sludge:—

Organic and volatile matter ...	64·7 —70·4 %
Minerals	35·3 —29·6 %
Nitrogen	3·75— 7·09 %
Phosphoric acid	2·1 — 4·2 %

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Many experiments have been made to determine the manurial effect of activated sludge, and the results have been most satisfactory. With wheat, it has been found that activated sludge is a better manure than dried blood, nitrate of soda, sulphate of ammonia, or gluten meal. Similar results have been obtained with other crops and plants. Taken all round, it may safely be said that its manurial value is at least as good as any of those fertilizers mentioned above.

The effluent obtained from this process is remarkably pure; it is not only extremely stable, but is clear and free from colloids, owing probably to the presence of a clotting enzyme in the activated sludge. This clotting, or clarification, is the first action which occurs, and is a sign that the purification is taking place correctly; it also enables the sludge to separate rapidly from the liquid after the aeration is effected; in fact, complete separation will usually take place in less than one hour. The effluent without further treatment will pass any of the usual standards, including those recommended by the Royal Commission on Sewage Disposal. It possesses a low saline ammonia content and high nitrification; it gives a low figure for absorbed oxygen and contains much dissolved oxygen owing to the aeration which takes place in the process; further, the bacteria are found to be reduced by about 98 per cent. It does, in fact, compare more than favourably with that obtained from percolating filters.

The following table of analytical results taken at Withington gives figures for different populations, but with the same tanks in use, and clearly shows the nature of the effluent obtained by this process. The figures give "grains per gallon."

	Rate of operation in gallons per diem.							
	150,000		250,000		375,000		500,000	
	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.	Sewage.	Effluent.
Oxygen absorbed in 4 hrs.	2·14	·44	1·66	·41	1·85	·42	1·97	·47
Free saline ammonia ...	1·75	·24	1·43	·28	1·52	·62	1·69	1·25
Albuminoid ammonia ...	·415	·07	·36	·07	·36	·07	·36	·08
Nitrites or nitrates ...		·93		·77		·46		·22
Dissolved oxygen absorbed		·36		·92		·88		·92
Suspended matter ...		less than 2		less than 2		2·0		2·18*

Reduction of bacteria in the effluent (all types) from 1 million to 20,000 per c.c. (98 %).

The details of the process can be seen from the plans of a typical plant which are reproduced. It is most important that all heavy grit

* An average of 30 determinations, varying from 1·1—3·7.

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and large floating solids should be removed before the sewage enters the aerating tanks. Detritus pits are therefore essential when rain water from yards or roads enters the sewers (these are not shown on the plans, which were designed for purely domestic sewage containing no rain water). After the separation of the grit, the sewage passes through a coarse screen (2) to the circular Disintegration Tank (4). The purpose of this tank is to break up all solid matter into small particles, so that a large surface will be available for the subsequent treatment. This disintegration is effected by blowing minute bubbles of air through the sewage from porous stone diffusers fixed in the bottom of the tank, in narrow furrows placed radially. A fine emulsion of air and water is thus formed, which, having a low specific gravity rises to the top carrying with it the solids, which are thus broken up mechanically. The air is given off at the surface of the liquid and the solids then tend to sink, and in a properly designed tank, every particle of solid matter is constantly carried up to the surface and then down again. It should be noted that although some aeration takes place in this tank, oxidization of the sewage is not carried out to any appreciable extent, for the aerobic bacterial culture, or activated sludge, is not present. The function of the air at this stage is solely for disintegration.

After this action the sewage flows through the fine screen (5) into the grease-collecting chamber. It is drawn off from the bottom of this chamber, so that any grease will collect at the top of the liquid and be trapped in the cylinder. It can be skimmed off and removed from time to time. The sewage then passes to the mixing chamber (6) where it is joined by a percentage of previously re-aerated sludge from the channel (12) and this is intimately mixed with the incoming sewage, and aerated by means of the diffuser (6*a*). The volume of activated sludge added varies from 15 to 30 per cent. according to the character of effluent desired. The lower figure will give a clear and stable effluent, but if complete nitrification is required, the larger volume is necessary.

The mixture then passes along the aeration channel (7) where the actual purification takes place. This is a long channel (about 135 ft. on the plan here shown) and is, in this case, in three lengths (each about 45 ft. long), the inlet being at (5*b*) and the outlet at (8). The length of the channel and its cross-sectional area depend on the nature of the sewage; the time of aeration usually required is 6 to 8 hours, but it may be as short as 2 hours, or as long as 24 hours. There are diffusers all along the channel, and the three necessary constituents for purification (sewage, air and activated sludge) are in intimate contact throughout the length. In order to prevent short circuiting the aeration channel is divided into compartments by baffle walls (7*c*) in which there are small openings immediately over the diffusers near the floor. In this channel the sewage is com-

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pletely purified, and the solids are " inoculated " and converted into activated sludge.

The air fulfils a threefold purpose in this work; it keeps the sewage in a constant state of agitation, it helps to coagulate the colloids, and supplies oxygen for the life of the aerobic bacteria, by means of which the purification takes place. For the latter part of the work, 2 c.f. of air per sq. ft. of tank area per hour are sufficient, but actually a much greater volume (6 to 9 c.f.*) is at present used. The air pressure depends on the depth of the tank, and need only be about $\frac{1}{4}$ lb. per sq. in. more than the pressure due to the liquid; usually 5 to 10 lbs. per sq. in. is sufficient. In the U.S.A. the compressed air is sometimes filtered to prevent it from clogging the pores in the diffusers.

After purification, the sewage passes through the orifice (8) down the feed-pipe (9*a*) to the Settlement Tank (9) which it enters by means of the Clifford Inlet. This consists of a vertical pipe discharging downwards into an eddy bucket (9*b*) which is supported inside a guard chamber (9*c*). The object of this is to break the force of the incoming sewage, so that the settlement of the sludge is not disturbed. Owing to the clarity of the effluent, the sludge is deposited very quickly, and in one hour, settlement is complete. The effluent is drawn off by the bell mouths (9*f*) and runs to a suitable outfall, no further treatment being necessary, except under exceptional circumstances.

The sludge is continuously being forced out through the outlet (9*k*) by the hydraulic pressure of the liquid above it, the rate of flow being regulated by the penstock (9*l*). It then enters the re-aeration channel (10), by means of which it returns to join the incoming sewage. The surplus increment of sludge due to treatment can be run off or pumped out of the channel at intervals, as found convenient. The sludge has a great avidity for oxygen and for this reason, that which is to be mixed with the incoming sewage should be re-aerated at this stage. There are diffusers along the length of the re-aeration channel for that purpose. After passing along this channel, the sludge is raised by two air-lift pumps (11 and 11*a*) to the level of the incoming sewage with which it then mixes.

If the sludge is left without aeration for a time, owing to cessation of the air supply, it will regain its useful properties after a period of aeration. Stoppages up to six weeks duration have occurred which have given no difficulty, and if the plant is occasionally shut down at night, or for one or two days, a few hours of aeration before admitting sewage will be quite sufficient.

* *Note.*—Actual volumes used per hour per sq. foot of tank surface are: Worcester=8 c.f.; Withington=9 c.f.; Tunstall=8 c.f.

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The process lends itself very readily to the varying rates of flow occasioned by storms. During the peak flow in dry weather, and during the first hour's flush of torrential rainfall, the first particles of sewage to pass through the tanks are liable to be not thoroughly oxidized. But during the small flow of weak sewage at night in dry weather the sludge becomes fully activated ready for the peak flow next day, and by increasing the tankage in order to carry, say, 50 per cent. surplus sludge above that required for the average dry weather flow, any storm flow can be successfully treated. It must be remembered that after the first hour's flow in torrential rain, the increase over the average dry weather flow is merely dilution, and thus actually less work is then required from the bacteria carried by the returned activated sludge.

It is of course necessary to design the sedimentation tanks of a sufficient size to take the maximum storm flow plus the returned sludge to be settled, and for this a stay of one hour in these tanks should be arranged for.

Normally, the outlet from the aeration tanks is by way of the restricted orifice (8), so that even during the peak flow in dry weather, or a storm, only a small volume passes through the tanks, and consequently the level in them then rises. This enables the first sewage arriving at the works after a storm (which is particularly foul owing to the washing down of roofs and drains) to receive additional treatment in the aeration tanks. The level continues to rise until the sewage can pass over the overflow weir (8*a*) and the subsequent storm water, which is comparatively pure, will then pass through with a short period of aeration.

The activated sludge process has many great advantages which enables it to approach that perfection which is claimed for it by its inventors; the chief of these are as follows:—

1.—The purification is rapid and perfect and the effluent fully oxidized.
2.—Putrefaction stops at once, and the system is free from smells and flies.
3.—The plant can be installed close to buildings, so that long outfall sewers are often unnecessary.
4.—An inoffensive sludge which is a valuable manure is obtained.
5.—Only a small area of land is required.
6.—There is practically no loss of head (4 in. to 10 in.) and the sludge is raised automatically.
7.—Trade wastes which are alkaline, or of constant but low acidity, give no difficulty.
8.—A very small staff is needed, but it requires at least one skilled attendant.

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9.—Capital costs are low owing to the simplicity of the plant, the small tank area needed (less than for sedimentation or septic tanks), and the absence of filter beds. Further, by installing the plant near a town, there may be a saving in the cost of outfall sewers.

10.—Maintenance costs are low owing to the revenue which may be obtained by the sale of manure.

Taken all round, the cost of installing and maintaining a plant is generally about two-thirds of the cost of septic tanks and filter beds. It should be mentioned that existing tanks can usually be converted, and in many places this has been done quite successfully at small cost.

The plants work well either with a large or small population, and would appear to be well suited for military stations. There are no real disadvantages in the system except possibly the production of compressed air, which is so essential for the working. In many places, compressed air is required for raising the sewage by means of ejectors, and no further compressing plant is needed. The expense of installing an air-compressor is not great.

The first large scale experiments in England, were carried out at Salford near Manchester in 1917. The results were extremely satisfactory, and the process is now becoming very well known in this country, and in the U.S.A. The Ministry of Health has recently sanctioned the erection of a plant at Reading to treat the whole of the town sewage amounting to 2,750,000 gallons per diem. The London County Council have just placed an order with Messrs. Activated Sludge, Ltd., for equipping a set of tanks at their Crosness Outfall Works to treat 110,000 gallons of sewage per diem, for the purpose of demonstrating the capability of the process to treat the sewage of London.

The entire patents for the process are held by Messrs. Activated Sludge, Ltd., of 14, Howick Place, Victoria Street, Westminster, to whom the writer is indebted, not only for much of the information given in this paper, but also for permission to reproduce the plans and photographs, by which it is illustrated.

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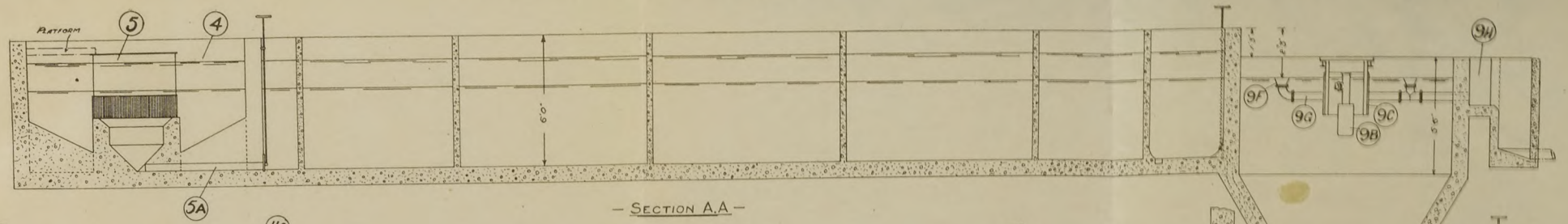
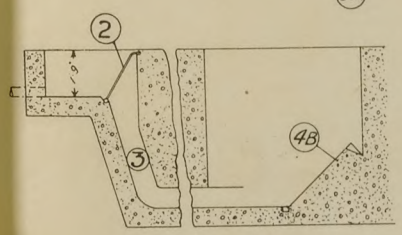
—Typical Activated Sludge Plant—



—Section A.A—



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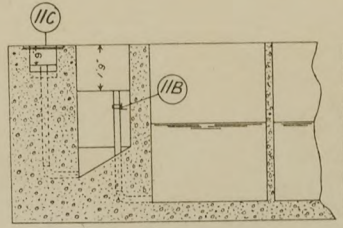

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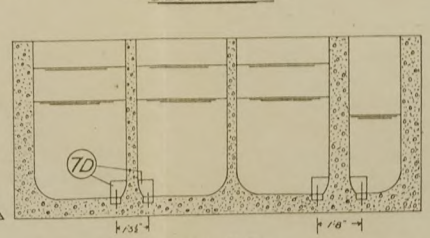

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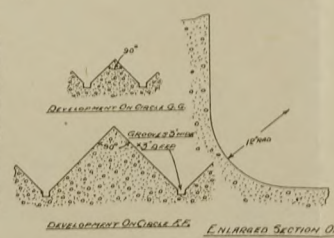

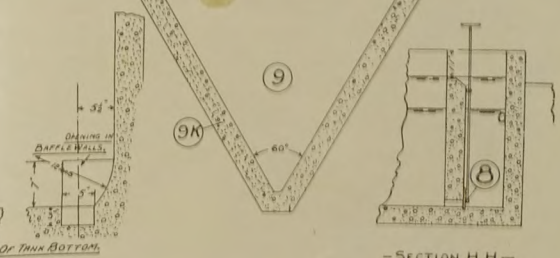

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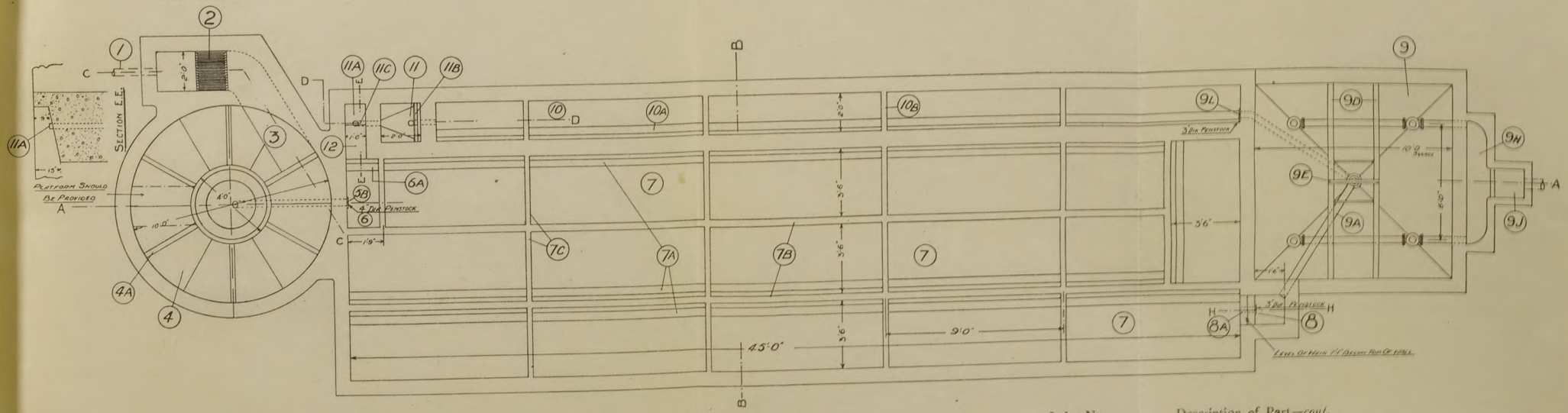

Index No.	Description of Part.
1	Inlet Sewer.
2	Coarse Screen.
3	Inlet Race to Disintegration Tank.
4	Disintegration Tank.
4A	Diffusers.
4B	Ridges.
5	Grease Collecting Chamber and Fine Screen.
5A	Inlet to Mixing Chamber.
5B	Penstock to cut off Dis. Tank from Aeration Tank.
6	Mixing Chamber.
6A	Diffuser.
7	Aeration Channel.
7A	Diffusers.

Index No.	Description of Part—*cont.*
7B	Longitudinal Partition Walls.
7C	Transverse Baffle Walls.
7D	Openings in Baffle Walls.
8	Restricted Orifice.
8A	Overflow Weir.
9	Settlement Tank.
9A	Feed Pipe to "Clifford Inlet."
9B	Eddy Bucket.
9C	Guard Chamber.
9D	Supporting Joists.
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9F	Effluent Outlet Bellmouths.
9G	Effluent Outlet Pipes.

Index No.	Description of Part—*cont.*
9H	Final Effluent Channel.
9J	Effluent Spill Chamber.
9K	Sludge Return to Re-Aeration.
9L	Penstock Controlling Return Sludge.
10	Re-Aeration Channel.
10A	Diffusers.
10B	Baffle Walls.
11	1st Air Lift.
11A	2nd Air Lift.
11B	Support for Eduction Pipe of 1st Lift.
11C	Support for Air Pipe of 2nd Lift.
12	Sludge Return to Mixing Chamber.

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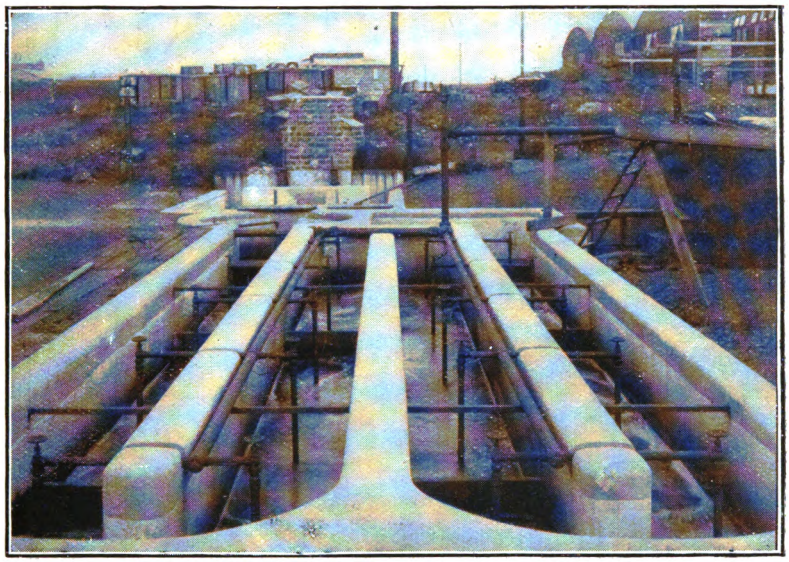

1.—National Filling Factory, Aintree.

This Government Installation for 2,000 workpeople has been in operation since 1916 and is still doing good service with reduced flow.

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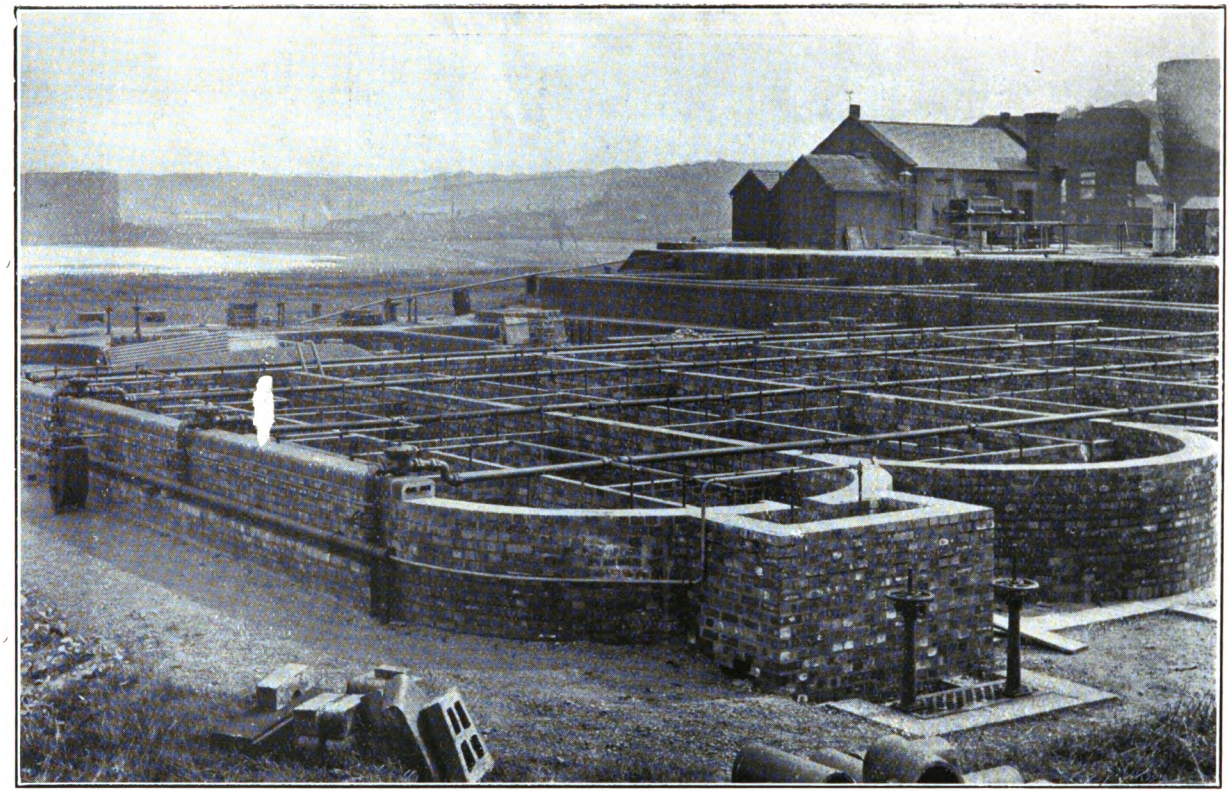

2.—Town of Tunstall, Stoke-on-Trent.

The Borough Sewage Engineer writes :—300,000 gallons per day is being treated efficiently and satisfactorily.

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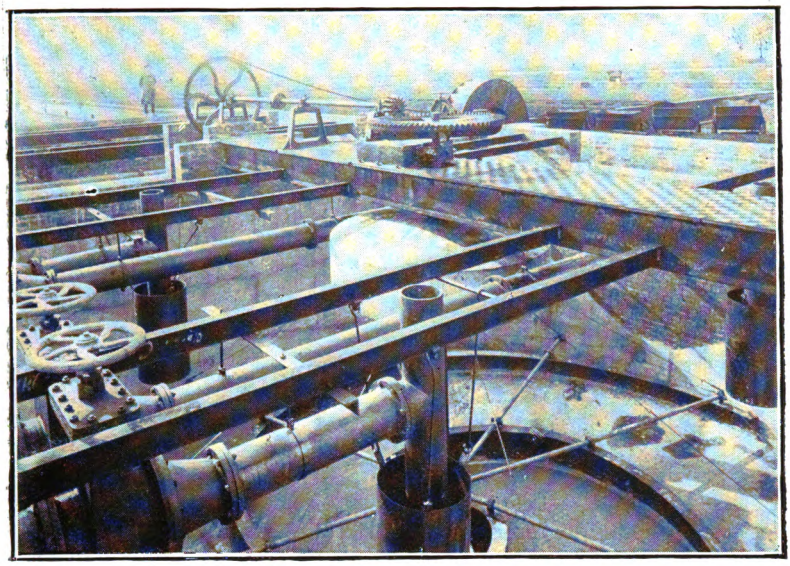
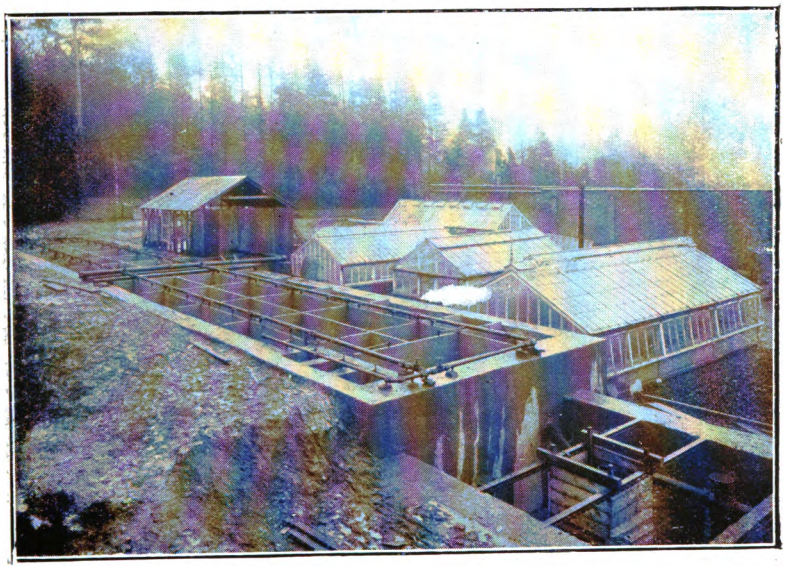


3.—Manchester Sewage Works at Davyhulme.

One of the Settlement Tanks before filling, showing patent inlet pipes and eddy buckets and helical scraper on dished bottom continuously rotated by water wheel operated by falling effluent.



4.—For American Red Cross Hospital, Southampton.

Population 2,000. A successful War Hospital scheme.

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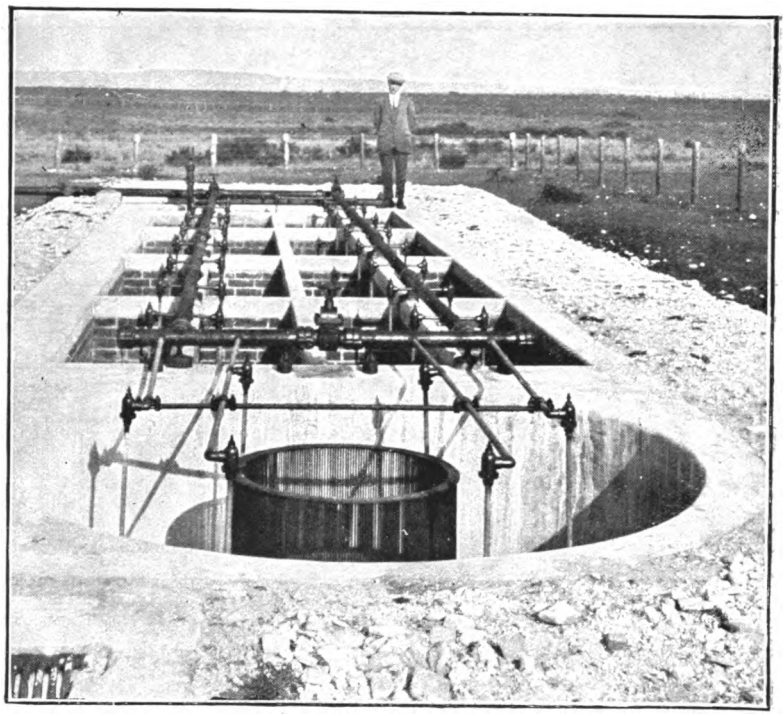

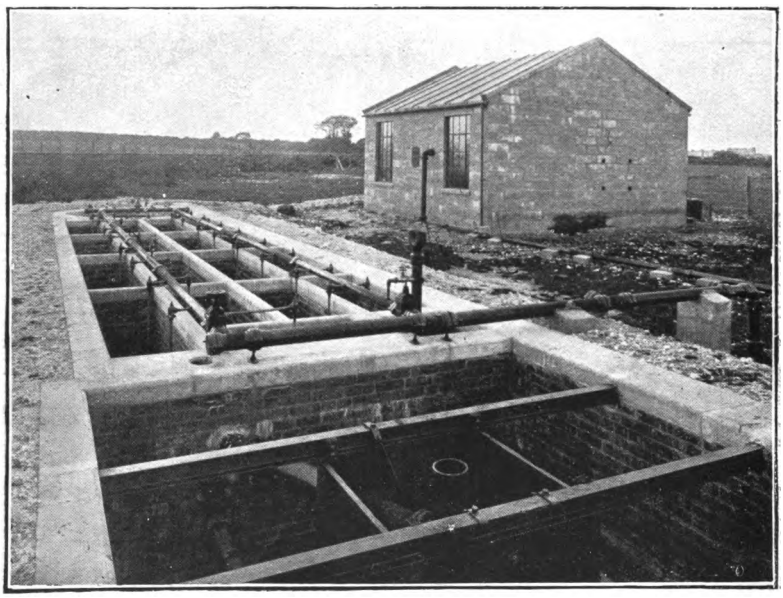

5. and 6.—For the Admiralty Airship Station, Moreton.

Population 400. One compressed air plant operates Ejectors and aerates the sewage.

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VERDUN AND METZ.

A Comparative Study of the Fortifications, taken from an Article in the "Revue du Génie Militaire" of January and February, 1921, by General Benoit, Chief Engineer of the Military Command of Metz.

By CAPT. C. LA T. TURNER JONES, D.S.O., M.C., R.E.

This study is subdivided into the following parts:—

I. The rôle allotted to Verdun and to Metz.
II. A historical summary of their fortifications.
III. The ideas prevailing in France and Germany on the organization of fortresses.
IV. The differences in the strength and construction of the works.
V. Constructional details of "Feste."
VI. The condition and cost to date of the fortresses of Verdun and Metz at the outbreak of war.
VII. Works carried out during the War.
VIII. The effect of bombardment on, and the part played by, these fortresses during the War.

I. THE RÔLE ALLOTTED TO VERDUN AND METZ.

Verdun and Metz on the Meuse and Moselle respectively, and some 60 miles apart as the crow flies, had somewhat similar rôles to play.

Verdun is a bridgehead on the Meuse and was the northern pivot, Toul being the southern, of the fortified region of the Heights of the Meuse, with a front of about 75 kilometres.

Metz is a bridgehead on the Moselle, a river quite as important as the Meuse, and with Thionville formed the fortified area of the Moselle, with a front of 45 kilometres.

The rôle assigned to Verdun and the Heights of the Meuse was:—

(1) To hold the approaches to the Meuse and to cover to a certain extent the concentration of the Field Army.

(2) To help any offensive action of the French Armies in the Woëvre and to safeguard their communications.

(3) In case of failure to guard the retreat of these Armies, to immobilize a portion of the enemy's forces and to threaten his communications.

The rôle assigned to the fortified area of the Moselle seems somewhat similar. It was:—

To cover the concentration of the German Forces in Lorraine

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and to give Germany the command of the crossings over the Moselle between Luxemberg and the French frontier to the south.

This fortified area of the Moselle had a great advantage over the Heights of the Meuse in being much nearer the frontier, thereby rendering easier an invasion of the French territory commanded by its guns and on the other hand preventing any attempt at invasions made by the French in the direction of Metz.

The outer forts of Verdun being 40 kilometres from the frontier were not able to be of the same use.

II. Historical Summary of the Fortifications of Metz and Verdun.

1st period: prior to 1870.—Before 1870 Metz being nearer the frontier than Verdun was better fortified; the latter had its citadel and its enceinte only, while the former had already some detached forts completed, namely:—Plappeville, Saint-Quentin, Queuleu and Saint-Julien—some under construction—Saint-Privat and Les Bordes; these forming a ring of forts round the enceinte and some three to four kilometres from the citadel.

2nd period: 1870–1886.—After the war of 1870 the Germans hastened the completion and development of these works. Between 1873 and 1880 they constructed Manstein (now Gérardin) and joined it to the existing fort of St-Quentin to form the "Feste" Frederick Charles. They also completed the ring of forts by adding Schwerin (now Decaen), Kameke (Déroulède) and Hindersin (Gambetta) and constructed earthen gun emplacements in the intervals between the forts. The development of Verdun was being carried out at the same time. Between 1874 and 1880 a ring of detached forts was begun two and half to six and a half kilometres from the citadel (Belleville, Saint-Miciel, Souville, Tavannes, Belrupt, Dugny, Regret, La Chaume and Marre) and also the fortifications of the Heights of the Meuse. About 1880 it was decided to occupy certain points further out from Verdun (five to eight kilometres) giving a good command over the approaches to the town. The foundation of this exterior ring was laid with the forts of Vaux, Moulainville, Rozellier, Haudainville, Landrecourt, Belle Epine and Douaumont.

3rd period: 1886–1899.—With the introduction of heavy howitzers the era of concrete began, and in 1888 the strengthening of the forts of the outer ring on the right bank of the Meuse was begun, and a few years later (1892–1897) that of those on the left bank. Earth works and earth battery emplacements were thrown up between the forts. Most of these works were provided only with simple masonry shelters, but it was intended to strengthen some later, viz., Froide-terre, Thiaumont, La Laufée, Charny. No armour was used before 1899 and ferro-concrete had not yet been introduced.

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At Metz strengthening was also being done; the Germans, however, did not confine themselves to concrete but completed their defences by the addition of cupolas and armoured observation posts. They installed two 21-cm. howitzers in revolving cupolas at Saint-Quentin, two more west of the farm of Chêne, and two 15-cm. guns at Fort Kameke. In 1897 they were energetically pushing on with five armoured batteries, each of four 15-in. howitzers, in the intervals between the forts, two near Plappeville, another east of the farm of Chêne, another near Queuleu and the fifth at Sablon. By 1899 there was only a single ring of forts round Metz as compared to the two lines round Verdun, but the former was probably the stronger on account of its 28 pieces of artillery mounted in cupolas and its numerous concrete shelters.

4th period: 1899–1914.—In 1899 the construction of an outer ring of works was begun at Metz consisting of the "Feste" Lothringen, Kronprinz and Kaiserin on the left bank of the Moselle, Haeseler on the right bank and in addition Guentrange on the left bank near Thionville.

These works were barely finished in 1905 when the Germans began the completion of the ring by starting the works of Wolfsberg, Vermont and Leipzig on the left bank of the river, and on the right bank the "Feste" Wagner and Luitpold, the works of Chesny, Lauvallière and Mey, and the somewhat distant batteries of Sorbey, Mont, Silly and Sainte-Barbe. The "Feste" von der Goltz was begun in 1907. Illange and Koenigsmachern on the right bank of the river near Thionville were begun in 1905 and 1908 respectively. In 1911 the Germans began the fortification of Horimont and the Quarries of Amanvillers, and, later, (1912–13) the organization of the interval between the "Feste" Kaiserin and Kronprinz. This organization consisted of a continuous obstacle defended by a series of closed works provided with concrete shelters.

Neither these works nor the "Feste" von der Goltz were completed by 1914, and they were continued till the 1st April, 1916, when the labour and material were diverted to the Southern Front for the construction of a defensive line having one flank on the right bank of the Moselle and extending to Sorbey *viâ* Pomerieux and Chérisey.

In France the period 1899 to 1914 was a period of armour and reinforced concrete. A Commission on Forts was formed in 1899 and in 1900 laid down a vast programme for the strengthening of works. This included disappearing turrets, armoured O.Ps. and Bourges casemates in the forts themselves and concrete shelters and battery emplacements in the intervals between them. This programme was carried out between 1902 and 1910, 1902 seeing the first armoured turrets in the Forts of Verdun.

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III. IDEAS PREVALENT SINCE 1899 IN FRANCE AND GERMANY WITH REGARD TO THE ORGANIZATION OF FORTS.

At Verdun.—The Forts at Verdun since 1900 were principally organized for their own defence and for that of the intervals between them. For their own defence they had machine guns, some in turrets and some not—also in some cases 75-mm. guns in turrets which were not to be used for the artillery duel but were to give a means of rapid fire to the works, and to ensure, in conjunction with the machine guns, the defence of the approaches to the work.

For flanking fire over the intervals the forts had guns placed either in concrete, *i.e.*, Bourges casemates, or under armour in disappearing turrets. The turrets primarily intended for flanking were not to be used until the last moment. In addition the forts usually being in the best fire position were sometimes provided with 155-mm. guns in disappearing turrets, each gun being allotted a specially important rôle. Nearly all these guns had shortened barrels. A few armoured O.P. were intended either for the artillery or for the Command. The garrisons of the forts were quartered in concrete barracks of some 3,600 beds, and were somewhat congested, there being only sleeping accommodation for two-thirds of the numbers detailed to the forts by the last "Instructions."

At Metz.—In 1899 the German conception of the rôle of forts was fundamentally different. They considered that long-range fire only was required and the essential feature of their works consisted of armoured batteries either built within the forts themselves, as at Saint-Blaise and Sommy (together forming the *feste* Haeseler), or else protected by infantry works surrounding the batteries and generally joined by a fire parapet. This is the system of fortification to which the Germans have given the name of "FESTE" (see *Fig.* 1) and which has been called "Offensive Fortification" in contra-distinction to the system used in France in which close-range fighting and the defence of intervals were chiefly considered.

The armament of the large *feste* on the left bank of the river usually consisted of two batteries of three 15-cm. howitzers, 12 calibres long, with a range of 7·2 km., and two batteries of three 10-cm. turret guns, 35 calibres long, with a range of 10·8 km. All these guns were mounted in revolving cupolas. Each battery had in its immediate vicinity at least one armoured O.P., and concrete barrack for the artillery garrison.

The infantry works protecting these batteries enclosed numerous O.Ps., machine gun emplacements, etc., in addition to the concrete barracks for the garrison.

A wire obstacle surrounded each work and each battery, while another encircled the *feste*. Underground galleries joined together the different parts of the *feste*.

These *feste* covered considerable areas, *e.g.*, Kronprinz 355 acres,

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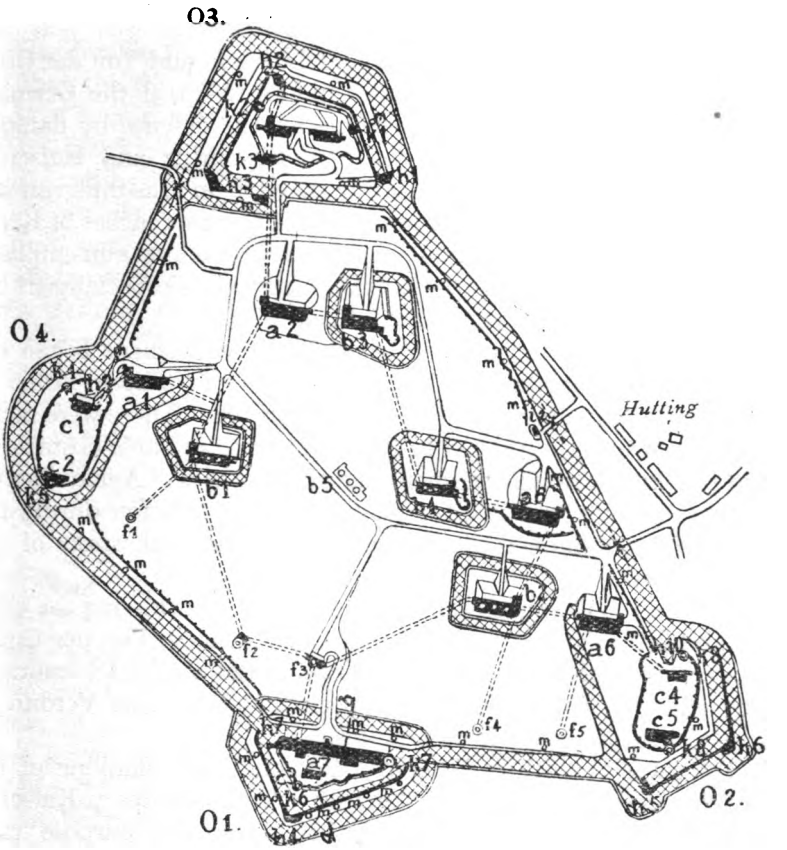
Kaiserin 330, and Von der Goltz 506. For concealment the ground within the *feste* was kept as far as possible unaltered. Camouflage was much used and the planting of creepers, trees, etc., resorted to.



LEGENDE

a 1.7	Concrete barracks.
b 1.2	Armoured 10 cm gun batteries.
b 3.4	" 15 cm. how. "
b 5	Dummy battery.
c 1.5	Picket shelter.
f 1	Revolving armoured O.P.
f 2.5	Armoured O.P.
h 1.6	Chambers or caponiers for enfilading the ditches.
h 7.8 / h 9.10	Casemates for enfilading the obstacles.
i 1.2	Blockhouses for enfilading approaches.
k 1.9	Armoured Infantry O.Ps.
m	Look-out post.
.....	Underground communications.
O 1 4	Infantry works.
═══	Trenches.

FIG. 1.—*Plan of a "Feste."* *Scale* $\frac{1}{16000}$.

1 c.m. = 10,000 cm. = 100 m.

The barrack "a 7" is about 150 metres in length.

Numerous dummy batteries and dummy observation posts were constructed. Ranging on the *feste* with ground observation alone would have been extremely difficult.

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The defence of the intervals was not at first considered at all and no battery or even single gun was cast for the exclusive rôle of giving the flanking fire, considered so important in the case of the French forts. It was only later, 1909 onwards, that the idea of flanking fire appeared in Germany. The *feste* Wagner and Mey built in this year had casemates for flanking fire, as also had Luitpold and Von der Goltz built in 1911. At about the same time (1912–1913) the Germans constructed machine gun emplacements for the defence by flanking fire of the interval between the *feste* Kronprinz and Kaiserin; and in 1915 Marival, the most southern work in this interval, was given a casemate for a 77-mm. gun to flank the approaches of Kronprinz. During the war the number of concrete machine gun emplacements for flanking fire was considerably increased, especially in the intervals between the forts N. and E. of Metz.

In 1911, to increase the defensive power, the Germans began the construction of large flanked ditches on the north-western front of the fortified area, in front of the *feste* Lothringen. These were never completed, but were intended to form a most formidable obstacle on a front of 6 km. between Horimont and the Quarries of Amanvillers.

The same policy was responsible for the construction during the War of two well-flanked ditches round the principal works of the *feste* Kronprinz.

In the end the Germans were more and more considering the close battle and introduced into their new forts (*i.e.*, Mey, Von der Goltz, etc.) accommodation for mining personnel and shafts for countermining galleries, works which had been undertaken at Verdun as soon as the outer ring of forts were built.

At the same time they directed attention to the flanking of the obstacles round the *feste*, which flanking, except perhaps at Kaiserin, had originally been omitted altogether. For this purpose they constructed small concrete works without much command, which were reached either across the open or by underground galleries. In the case of Von der Goltz large concrete emplacements were built in 1914 which covered a considerable area and gave perfect flanking fire.

The forts were usually supplied with water from wells or springs outside them, and the pumps, etc., were liable to damage from a lucky shot. In the later works the wells were dug under the concrete barracks.

From the above it is clear that the German ideas, which in 1899 were almost entirely offensive, changed gradually to the defensive; this evolution can also be seen in the details of the works themselves. At first the buildings were not, as might be expected from the German character, proof against all shell; even ten to fifteen years after the introduction of high explosive shell the walls of barracks and batteries were still being built comparatively weak, and it was not till ten

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years after their construction that steps were taken to strengthen them.

It was only shortly before the war, in 1911 and more particularly about 1913, that obstacles suitable for a really determined defence were considered desirable and that wide ditches or counterscarps of considerable thickness were constructed. It was about this time too that the thicknesses of walls and roofs were increased and use made of ferro-concrete.

This change is also noticeable in the armament of the *feste*, the number and power of the guns tended to decrease whilst the arrangements for close defence increased, *i.e.*, concrete emplacements for 57-mm. guns and for machine guns, bomb throwers, and concrete parapets provided with traverses and parados.

Everything thus tends to show a change in the conception of the rôle to be played; it seems that in the beginning the Germans did not fear any attack in force on Metz, and so developed only the offensive possibilities of the place; it was only latterly that they foresaw a possible defence against a serious attack, and made a tremendous effort, continued during the War, to make the place one extremely difficult to capture.

IV. The Difference in the Strength and Construction of the Works.

The Strengthening of the Old Works.—At Verdun the casemates were strengthened in 1886 by the addition of a layer, generally 2½ m. thick, of concrete, to the original masonry and separated from it by a layer of sand 1 m. thick. At Douaumont the eastern face was given only 1½ m. of concrete.

Similarly at Metz the strengthening consisted of the addition of a layer of sand 1 m. thick and then 1 to 2 m. of concrete.

Concrete and Ferro-Concrete.—In the works built at Verdun since 1900 ferro-concrete was much used, in thicknesses varying from 1·2 to 1·8 m. for floors and roofs, while walls were usually of special concrete.

At Metz, up to about 1900, the new walls and roofs were made similar to the strengthened ones. In 1900 masonry and sand were dispensed with and special concrete 2½ to 3 m. thick was used. Still later ferro-concrete was used, an outer layer 1 m. thick and an inner one of 0·20 m. separated by 1 to 2 m. of special concrete. In the more recent works this inner layer was often replaced by metal troughing.

For the permanent works built since 1914 the inner layer of ferro-concrete was increased to 0·50 m. and the steel troughing retained in addition; iron bars of 20 mm. diameter connected the two layers

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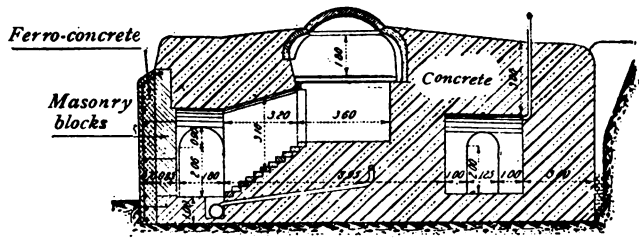
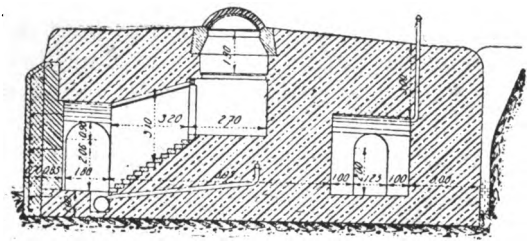
of ferro-concrete together. In some works 1 m. of ferro-concrete was added to the outside of the existing works giving a total thickness of 3½ m. This is the case at Guentrange. The outer walls of batteries and barracks were originally of masonry only, to these in many cases 1 m. of ferro-concrete was added; in the new works they were built of 1·5 m. of special concrete and 1 m. of ferro-concrete. About 1914 walls and floors of less than 2 m. thickness were made entirely in ferro-concrete.

Armour.—Armour has been much more frequently used in Germany than in France and armoured casemates were highly thought of in spite of their heavy cost and of the fact that they are barely stronger than concrete ones.

Armoured guns at Verdun were in disappearing turrets, whilst at Metz they were in revolving turrets. These turrets consist of a cupola and a shield built into a protecting block of concrete. The cupolas for 10-cm. guns or 15-cm. howitzers are of nickel steel 0·16 m. thick, lined with mild sheet-steel 0·04 m. thick. Those for 21-cm. howitzers are made of two metal plates, 0·13 m. and 0·075 m. thick respectively, separated by a layer of lead 0·020 m. thick and lined with sheet-steel 0·04 m. thick. These latter are older than the former



Section through a battery of 15-cm. howitzers.



Armoured Battery.

Legende.—1, Flanking casemate; 2, Stores; 3-4, Command posts; 5, Barracks; 6, Cleaning Cartridges; 7, Filling Cartridges; 8, Setting Fuzes; 9, Magazine; 10, Turrets; 11, Latrines.

and date, in fact, from before 1892. The interior diameter of the floor of the cupolas is 2·80 m. for the 10-cm. guns, 2 m. for the 15-cm. howitzers and 4 m. for the 21-cm. howitzers. The shields are composed (*a*) for the 10-cm. long and short guns of six segments of nickel

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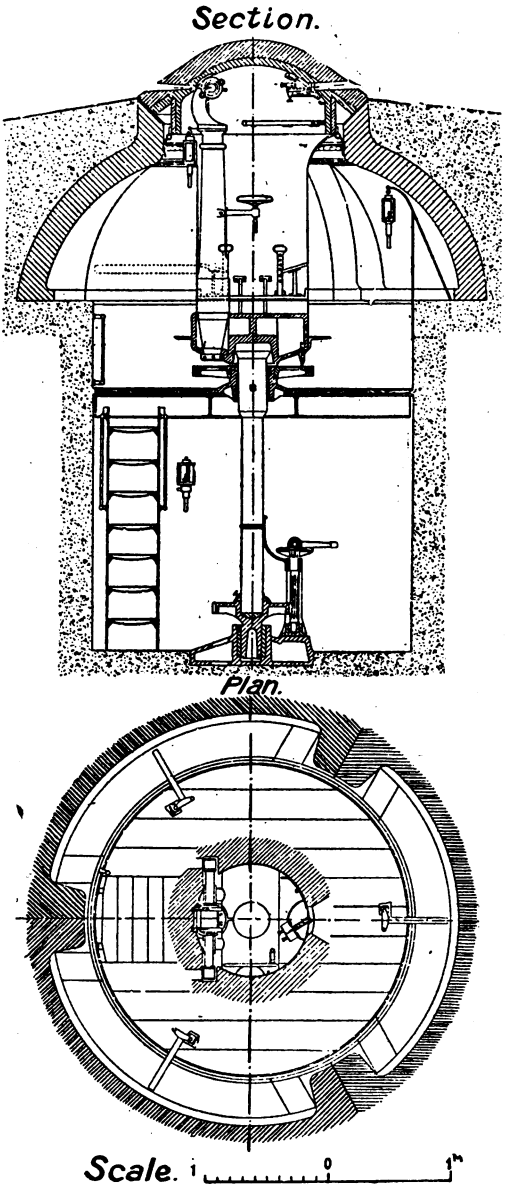

Revolving O.P.

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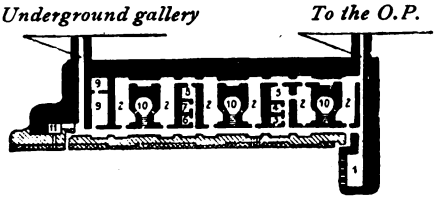
steel 0·20 m. thick connected by riveted flanges, (*b*) for the 15-cm. and 21-cm. howitzers of four segments of cast-iron 0·605 m. thick at the top and 0·30 thick at the bottom. The cost of the armour for the 10-cm. guns was between 126,000 and 158,000 marks, and that for the 15-cm. howitzers about 63,800 marks.

Observation Posts.—Observation posts are either fixed or revolving. The former usually consist of a steel dome with 0·50 m. command over the surrounding concrete. The diameter of the O.Ps. is usually 1·15 m. to 1·30 m., and sometimes as much as 1·50 m.; 1 m. is not sufficient to use instruments with any comfort. The thickness of the steel is from 0·20 to 0·25 m. and the height varies from 1·70 to 2·25 m. Sometimes the O.P. consists of a rectangular chamber covered with concrete, or better with a special steel plate 0·20 to 0·30 m. thick. Revolving O.Ps. are 1·15 m. in diameter at the height of the table (see *Plan*). They are installed in pits of 2·60 m. diameter and 4·50 m. deep, made in a heavy mass of concrete and in communication with neighbouring works. The top of the pit is protected by a shield of nickel steel 0·20 m. thick and 1·50 m. high. The cupola of the observation post is made with a spherical roof of nickel steel 0·16 m. thick, lined with mild sheet-steel 0·04 m. thick. These posts can be actuated easily by the observers.

V. Constructional Details of the Feste.

Armoured Batteries.—All the batteries are of the same type and, having no command, are practically invisible to ground observation. The turrets are placed in one line about 20 m. apart and are merely revolving. Two, three or four make up a battery. Each battery has only one type of artillery, either 21-cm. howitzers (maximum range 9 km.), 15-cm. howitzers (12 calibres, range 9·700 km.) or 10-cm.



Section through a battery of 10-*cm. guns.*

guns (35 calibres, range 10·800 km.). Each turret contains one gun and one spare tube only. This armament was for the most part left *in situ* by the Germans, who, however, removed their 21-cm. mortars in 1916, as they were of bronze, and emptied and destroyed their ammunition.

The working of the guns is very easy; it is all done by hand, the cupola in its fire position being raised slightly above its shield and

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when out of action resting on it. The shell are brought to the gun by a lift from magazines close at hand.

Each battery contains a small room for the men, a magazine, a command post with telephonic and aural apparatus, and a shell and cartridge store per gun. Most of the batteries have a concrete caponier at one end for the defence of the battery by rifle fire. The battery has its gorge closed by a defended railing and is surrounded by a wire obstacle defiladed by an advanced glacis. The battery is connected to its observation post by an underground gallery and by telephonic and aural communications. When the gallery is too long or too exposed, egress from the observation post to the open is arranged for by a ladder from the pit under the O.P.

Infantry Works.—Each infantry work was surrounded by a ditch, a covered way and a wire obstacle. At the top of the masonry or concrete counterscarp was a defended railing ; the escarp was replaced by a gentle slope at the bottom of which was a defended railing. At the bottom of the ditch was a wire obstacle, sometimes extending over the lower portion of the escarp slope. The enfilading of the ditches was arranged for from concrete chambers which were provided with nearly horizontal railings to prevent any enemy throwing missiles into them after gaining access to the covered way. The chambers were joined together by a counterscarp gallery connected to the interior of the work by a single underground passage. The concrete barracks formed the gorge, and this was enfiladed by a caponier. The armament of the caponiers and chambers usually consisted of two 57-mm. guns, but there was a growing tendency to use machine guns.

Covered Ways.—More importance in many works was attached to the covered way than in France. In the more recent works access to it was obtained either from one of the counterscarp chambers, or from the counterscarp gallery, by means of a ladder and a well.

It was enfiladed by concrete blockhouses placed either above these entrances or at the corners of the covered way.

Obstacles.—The obstacle can be observed from small observation posts of concrete or iron and is sometimes enfiladed from small concrete works. The depth varies, and is often 25 to 30 m. In the newer works the obstacle consists often of three strips of wire entanglement 10 m. deep separated by gaps of 10 m. The height of the pickets is never uniform, in order to make the obstacle more difficult to cross.

The Parapet.—The parapet of the infantry works was at first of earth, which was afterwards concreted in places. In the newer works the infantry position included a concrete parapet with splinter-proof shelters, traverses every 8 m. and a parados, the whole built of reinforced concrete 0·30 m. thick. It enclosed concrete machine gun and 57-mm. gun positions, look-out posts, and guard posts provided with an armoured infantry O.P. and so placed as to enfilade

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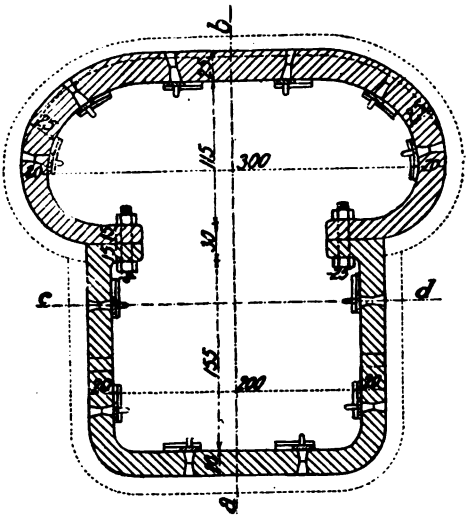
PLAN.



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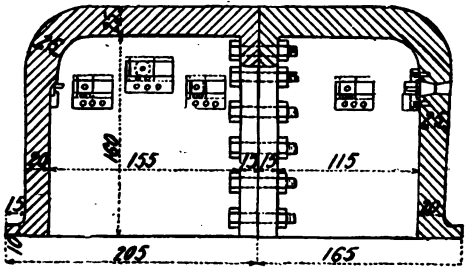

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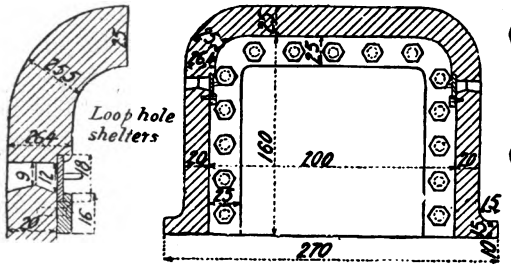

Dimensions of loop holes

(a) *Inside and outside*

(b) *In the middle*

Infantry Armoured Fighting Shelter.

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Planche I

REGION FORTIFIEE DES HAUTS DE MEUSE

Echelle 1 : 200.000.

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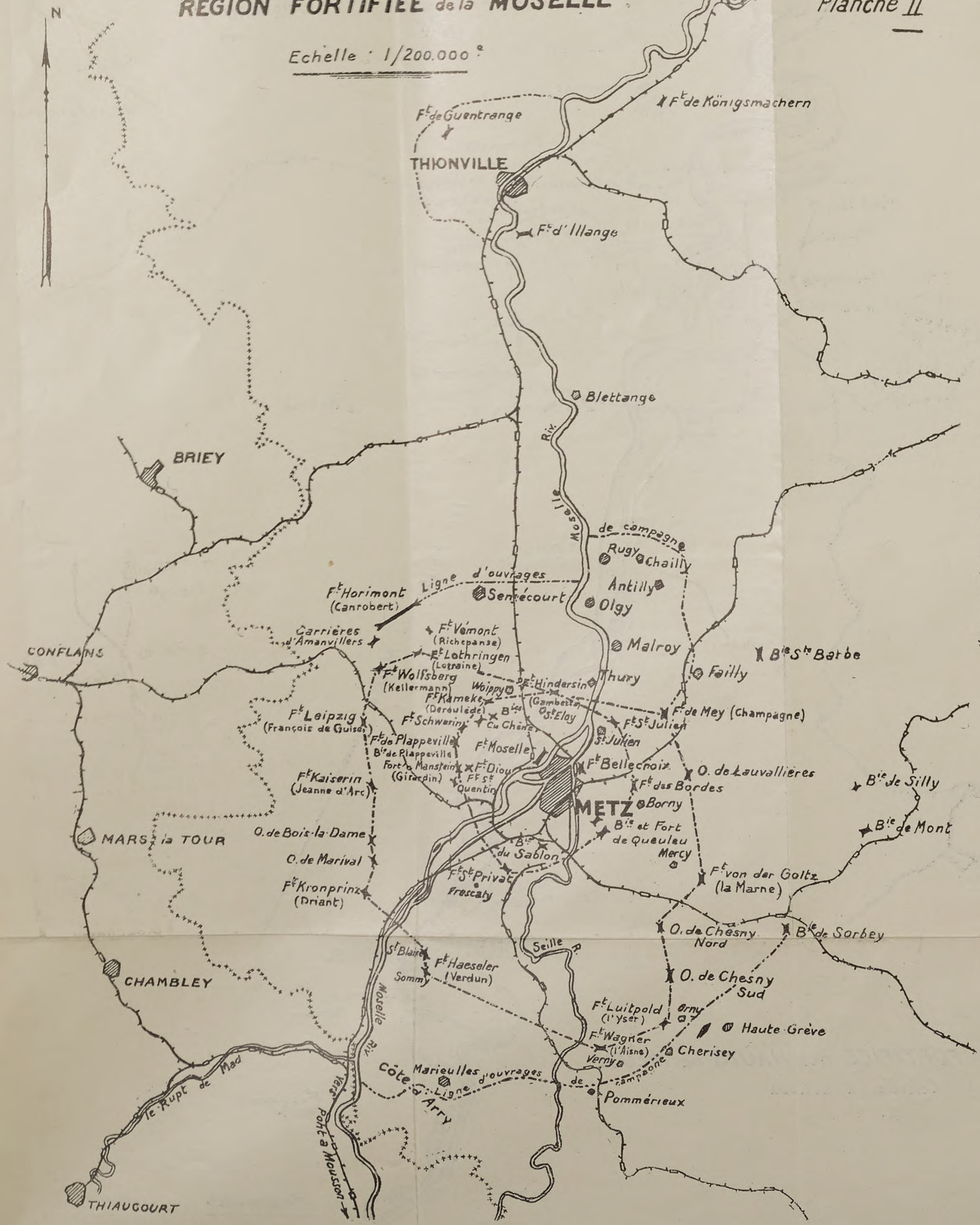
RÉGION FORTIFIÉE de la MOSELLE

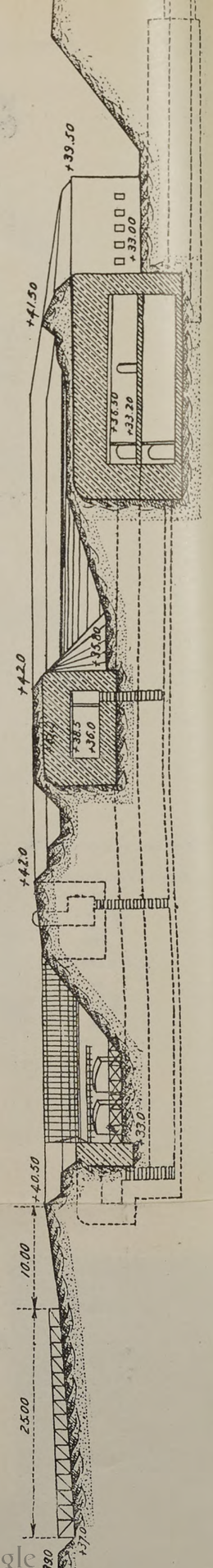
Planche II

Echelle : 1/200.000e



"Feste" de Metz

Coupe d'un ouvrage d'infanterie — Echelle 1/500



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the fire step. Close to the firing line there were many concrete shelters for piquets in communication with an armoured O.P. and able to fire into the work. These shelters were often connected underground to the sentry posts and always to the concrete barracks.

The Concrete Barracks.—The concrete barracks consisted usually of an upper storey, a ground floor, and often of a basement, each having one or two long corridors and at least one staircase at each end. The barracks usually included kitchens, bakery, hospital with bath rooms and operating theatre, dining rooms, magazines, reservoirs, central heating and 3 to 10 dynamos under ground level or on the ground floor. The upper floor usually contained barrack rooms with hammocks, a telephone exchange of 120 to 180 lines capacity, the various command posts and at one end (in the newer works) the casemates for giving enfilade fire on the gaps.

The various works defending the *feste* were joined by fire parapets with shelters of greater or less strength, and sometimes provided with O.Ps. and shelters for garrison troops.

(*To be continued*).

THE SIEGE OF MAUBEUGE.

THE German operations at the Siege of Maubeuge, August–September, 1914, have been described in detail by the officer in charge of them, General von Zwehl, in his book *Maubeuge—Aisne—Verdun.* An excellent summary of his account appears in French, in the *Revue Militaire Générale* for April, 1921. The story from the French side will be found in *La Verité sur le Siège de Maubeuge,* by Commandant Paul Casson, who was on General Fournier's staff. Will some officer of the Corps volunteer to prepare an account in English? The siege is of special interest to the Corps, as General Fournier is an officer of Engineers.

J.E.E.

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PROFESSIONAL NOTES.

NOTES ON BOX GIRDER BRIDGE.

Designed by MAJOR G. LE Q. MARTEL, D.S.O., M.C., R.E.

[CONTRIBUTED BY R.E. BOARD.]

WITH the exception of the Inglis Pyramid Bridges, all the girder bridges which were produced during the War, were designed to carry the heaviest loads, including heavy tanks. Towards the end of the War, however, a demand for medium girder bridges became apparent. These bridges were required on side roads, which would only have to carry medium loads, and in the initial stages in an advance, when it was urgently necessary to provide a long bridge at certain points. Moreover, in Colonial warfare, the heaviest loads to accompany an army would often be medium loads, and both the total weight and time of erection for a medium bridge can be brought considerably lower than those required for a heavy bridge. At the end of the War, when a considerable number of different types of girder bridge was in existence, there was some doubt as to the advisability of introducing further types of medium girder bridge, and on considering the whole question it became clear that what we required, was one type which could be built up into a light, medium, or heavy girder bridge according to requirements, and with any desired length of span. With a view to fulfilling this requirement, Major Martel has designed a bridge known as the Box Girder Bridge. The bridge is of the deck type and the chesses rest directly on the girders, so that no transoms or road bearers are required. The girders are skeleton steel box girders, 4 ft. deep and 2 ft. 4 ins. wide. They are made up in sections, each section being 8 ft. long (*see* diagram) ; the girders can therefore be made up to any desired length. One section weighs 12½ cwt. and is quite capable of being man-handled. The sections are joined together by plain pin joints ; no nuts or bolts are required. Either two, three, or four box girders are slung across the gap, according to the span and the load to be carried. The chesses are then laid on the girders, and kerbs and handrail complete the bridge. There are thus only two essential parts to the bridge—the sections of box girder and the chesses. It was thought at first, that a deck bridge would be unsuitable because of the restriction imposed on the waterway, but when it is remembered that the girders are only 4 ft. deep and that the roadways of the

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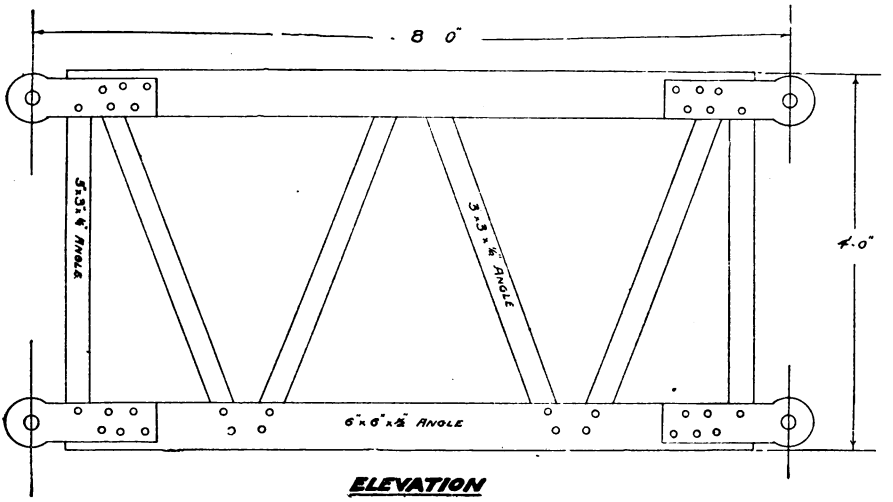
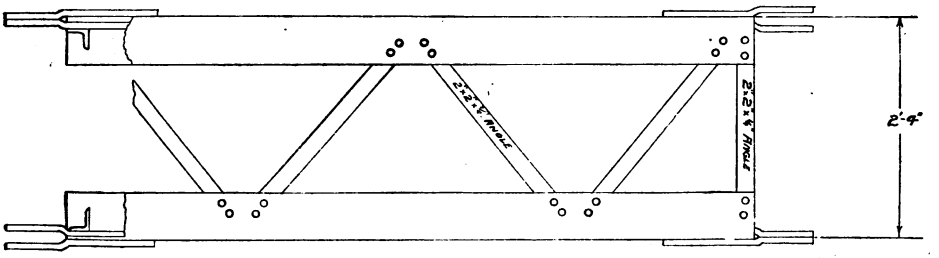
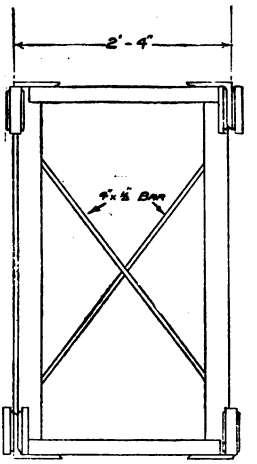


ELEVATION



PLAN



END VIEW

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ordinary through bridges are usually at least 2 ft. deep, it seems that a very small amount of ramping will enable the same waterway to be left with this type of box girder bridge as with a normal through bridge.

The following table shows the limiting spans for which the bridge will carry the various loads :—

No. of Box Girders used.	*Load.*	*Limiting Span in feet.*
2	Light loads	96
	Medium loads	72
	Heavy loads	48
3	Light loads	112
	Medium loads	88
	Heavy loads	64
	Heavy tanks	64
4	Light loads	120
	Medium loads	96
	Heavy loads	80
	Heavy tanks	80

There is a further advantage in this type of bridge, namely that any desired width of roadway can be constructed. To obtain a wider roadway it is merely necessary to add more box girders and use longer chesses, or a double row of chesses. By dispensing with the necessity of using transoms and road bearers, a considerable saving in weight has been effected. A comparison with existing types is as follows :—

Span.	*Type of Bridge.*	*Total Weight.*
60 ft.	Hopkins' 75-ft. Type	32 tons.
60 ft.	60-ft. Span Mark II.	32 tons.
60 ft.	Inglis Rectangular Mark II.	24 tons.
64 ft.	Box Girder Bridge using 3 girders	17.6 tons.

All these bridges will carry heavy tanks. A total of 48 sections of this bridge has been manufactured and is beginning to arrive at the Experimental Bridging Centre, Christchurch, and preliminary trial has shown that the sections can be coupled together very easily and rapidly. A single length of 96 ft. of Box Girder was built up and loaded until the steel was stressed slightly above 7·5 tons per square inch (the working stress at which the bridge is designed). After the initial stretch had been taken the girder was found to deflect 4¼ ins. under the full load. The top of each section is made a little longer than the bottom to provide a camber which was found to be 1-120th unloaded and this was reduced to about 1-240th when loaded. Although a 4-ft. girder is somewhat shallow for so long a span as 96 ft. the girder appeared to be comparatively

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rigid and a deflection of 4¼ ins. is not excessive under full load for this span. It is hoped that this bridge may replace all the existing types of the shorter span girder bridges. It is proposed to launch the bridge by running out the girders over rollers, and using short shear legs and preventer tackle. As a 96-ft. length of girder only weighs 7½ tons, the launching should present very little difficulty. A further account of this bridge will appear in the Professional Notes when the bridge has been thoroughly tested.

CONSTITUTION OF R.E. BOARD.

THE R.E. Board has been constituted to carry out the duties formerly allocated to the R.E. Committee. Its duties and objects are briefly as under.

1. *Objects.*—The Board is appointed with a view to the prosecution and guidance of Scientific Research, and for experiment and design in connection with Engineering equipment and material required for the Royal Engineers and the Royal Corps of Signals, and to act as an intermediary between the War Office and the productive engineering resources of the community in carrying out the general line of policy laid down by the General Staff in regard to such material and equipment.

It is also responsible for studying the progress made by the above-mentioned branches of the Service in foreign Armies, and developments in engineering in foreign countries.

2. *Duties and responsibilities of the Board.*—

(*a*).—Research and Investigation.
(*b*).—Experiments.
(*c*).—Design of technical machinery, material and stores for Military Engineering and Signals.
(*d*).—Records and Intelligence.

3. *Constitution and Organization.*—The Board consists of a permanent central body composed of a President, three Members and a Secretariat, who have no other duties, together with certain *ex-officio* Members. With them are associated representatives of other Experimental and Educational Establishments, of the branches of the War Office concerned, selected Regimental Officers, and representatives of other Government Departments and Engineering Institutions.

The constitution of the Board and of its three main Committees is shown in the following tables :—

THE BOARD.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (A).—Bt.-Col. R. A. Gillam, C.M.G., D.S.O., R.E.
Member (B).—Major A. D. Carden, D.S.O., R.E.
Member (C).—Major A. C. Fuller, R.C. of Sigs.

Associate Members.

Deputy Director of Staff Duties.—Bt. Lt.-Col. O. H. L. Nicholson, C.M.G., D.S.O., W. Yorks. Regt.
Assistant Director of Fortifications and Works (F.W. 9).—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
Commandant, School of Military Engineering.—Maj.-Gen. H. F. Thuillier, C.B., C.M.G.
Commandant, Signal Training Centre.—*Col. Com. E. G. Godfrey-Faussett, C.B., C.M.G.
Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Ex-officio.

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Representatives of
- Department of Scientific and Industrial Research.—Sir Joseph Petavel, K.B.E., F.R.S.
- Cambridge University, Engineering Faculty.—Prof. C. E. Inglis, O.B.E., M.A.
- Instn. of Civil Engineers.—Sir Brodie Henderson, K.C.M.G., C.B.
- Instn. of Mechanical Engineers, Sir John Dewrance, K.B.E.
- Instn. of Electrical Engineers.—Mr. C. H. Wordingham, C.B.E.
- Physical Society.—Mr. C. R. Darling, F.I.C., F.I.P.

Secretary.—Bt. Lt.-Col. J. G. Fleming, C.B.E., D.S.O., R.E.

(A) COMMITTEE.

Duties.

Bridging, Mining, Camouflage, Survey, and Field Service equipment for the Royal Engineers and the Royal Corps of Signals, other than that dealt with by Committees (B) and (C).

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (A).—Bt.-Col. R. A. Gillam, C.M.G., D.S.O., R.E.
Director of Military Intelligence (M.I. 4).—Lt.-Col. E. M. Jack, C.M.G., D.S.O., R.E.
Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Chief Instructor in Fortification, School of Military Engineering.—Major H. W. Herring, M.C., R.E.
Chief Instructor in Surveying, School of Military Engineering.—Major L. N. F. I. King, O.B.E., R.E.
Commanding Royal Engineer of a Division.—Bt. Lt.-Col. G. F. B. Goldney, C.M.G., D.S.O., R.E.
Chief Instructor, School of Artillery.—Major M. N. McLeod, D.S.O., M.C., R.E.
Representative of the Ordnance Survey.—Bt. Lt.-Col. H. St. J. L. Winterbotham, C.M.G., D.S.O., R.E.
} For Survey questions only.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Staff Duties.
  - Bt. Lt.-Col. M. F. Day, M.C., K.O.Y.L.I.
  - Bt. Lt.-Col. O. H. L. Nicholson, C.M.G., D.S.O., W. Yorks Regt.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.

Superintendent of Research, Woolwich.—Comdr. H. C. Goolden, O.B.E., R.N.
Director of Inspection, Chemical (Woolwich).—Mr. W. L. Baillie.
Representative of Naval Mining School (Admiralty), for Mining.—
Representative of Local Defence Division (Admiralty).—Major G. Rutledge, R.M.A.
Representative of School of Army Co-operation (Air Ministry).—Wing-Comdr. E. L. Gossage, D.S.O., M.C., R.A.F.
} For Camouflage.
Representative of Director of Research (Air Ministry).—Wing-Comdr. A. D. Warrington-Morris, C.M.G., O.B.E., R.A.F.
Assistant Secretary (A).—Lieut. E. N. Clifton, R.E.

Technical Establishments.

Experimental Bridging Company, R.E.—Bt.-Major A. V. T. Wakely, M.C., R.E.
Experimental Section, R.E.—
Camouflage Experimental Establishment.—Capt. C. le Breton Simmons, R.A.

(B) COMMITTEE.

Duties.

All Electrical and Mechanical services dealt with by the Royal Engineers and Royal Corps of Signals, including Searchlights and Sound Locating.

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.
Member (B).—Major A. D. Carden, D.S.O., R.E.

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Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Chief Inspector of Royal Engineer Stores.—Bt. Lt.-Col. A. E. Davidson, D.S.O., R.E.

Chief Instructor in Electricity, School of Military Engineering.—Major G. Thorp, O.B.E., R.E.

Chief Instructor in Workshops, School of Military Engineering.—Bt.-Major H. H. Bateman, D.S.O., R.E.

Commandant, School of Electric Lighting.—Major P. S. Watkins, D.S.O., R.E.

Commandant, Anti-Aircraft Searchlight and Sound Locator School.—Capt. D. R. St. J. J. ffrench-Mullen, R.E.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Staff Duties.
  - Bt. Lt.-Col. B. L. Eddis, D.S.O., R.E.
  - Bt. Lt.-Col. R. K. A. Macaulay, D.S.O., R.E.
- Director of Military Operations.—Bt. Lt.-Col. M. St. L. Simon, C.B.E., R.E.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.
- Director of Inspection, Chemical (Woolwich).—Mr. W. L. Baillie.
- Director of Torpedoes and Mining (Admiralty).—Capt. A. P. Addison, C.M.G., R.N. } For Searchlights.
- H.M.S. "Vernon"—Lt.-Comdr. A. Willis, R.N. } For Searchlights.

- Director of Naval Ordnance (Admiralty).—Comdr. Geoffrey Nicholson, R.N.
- Director of Research (Admiralty).—Mr. F. E. Smith, O.B.E., F.R.S.
- Representative of Director of Research (Air Ministry).—Wing-Comdr. A. D. Warrington-Morris, C.M.G., O.B.E., R.A.F.
- Controller of Communications (Air Ministry).—Group Capt. L. F. Blandy, D.S.O., R.A.F.

} For Sound Location.

Assistant Secretary (B).—Capt. M. T. Tudsbery, Genl. List.

Technical Establishments.

Searchlight Experimental Establishment.—Col. A. E. Le Rossignol, C.B., T.D., M.I.C.E., M.I.E.E., R.E. (T.).

Signals Experimental Establishment (for Sound Locating).—Lt.-Col. A. G. T. Cusins, C.M.G., R.C. of Sigs.

(C) COMMITTEE.

Duties.

Signals Equipment and Apparatus.

Members.

President.—Col. A. G. Stevenson, C.B., C.M.G., D.S.O., R.E.

Member (C).—Major A. C. Fuller, R.C. of Sigs.

Representatives of
- Director of Fortifications and Works.—Lt.-Col. H. G. K. Wait, C.B.E., D.S.O., R.E.
- Director of Staff Duties (S.D. 6).—Lt.-Col. H. C. Smith, D.S.O., R.C. of Sigs.
- Signal Training Centre.—Bt.-Major J. R. Pinsent, D.S.O., R.C. of Sigs.
- Chief Inspector of Royal Engineer Stores.—Major C. J. Aston, M.C., R.E.

Associate Members.

Representatives of
- Quarter-Master-General.—Lt.-Col. D. Paul, C.B., C.M.G., C.B.E., M.I.M.E., R.A.O.C.
- Director of Military Intelligence (M.I 1(B)).—Bt.-Major H. I. Allen, D.S.O., N. Stafford Regt.
- Director of Artillery.—Bt. Lt.-Col. N. Eliot, C.B.E., R.A.
- Engineer-in-Chief, Post Office.—Major T. F. Purves, O.B.E. (G.P.O.).

Assistant Secretary (C).—Capt. W. B. H. Carr, R.E.

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Technical Establishments.

Signals Experimental Establishment.—Lt.-Col. A. G. T. Cusins, C.M.G., R.C. of Sigs.

4. *Procedure.*—The Board will meet as required to consider general questions; normally the work will be carried out by committees. The committees as at present arranged are—

(i.)	Bridging	Committee A.
(ii.)	Mining, Demolitions and Explosives	
(iii.)	Camouflage	
(iv.)	Survey and Photography	
(v.)	General Field	
(vi.)	Electric and Mechanical Equipment, Water Supply ..	Committee B.
(vii.)	Searchlights	
(viii.)	Sound Locators and Acoustics	
(ix.)	Signals, General	Committee C.
(x.)	Signals, Wireless	

The President will arrange for the attendance of such Members, Associate Members, etc., as may be concerned in the Agenda of each Meeting.

Representatives of the General Staff should be invited to attend all Meetings.

The dates of Meetings will be fixed by the President.

The President, if present, will preside at all Board and Committee Meetings. If the President is unable to attend, the Chair will be taken by the senior Member of the Board present.

The President will regulate the proceedings of the Board, and will, from time to time, lay down such regulations or bye laws as he sees fit for the distribution of work and the dispatch of business.

Any question of overlapping between the Committees will be dealt with at once by the President by referring any recommendation of a Committee to the Board, or otherwise, but unless he considers this necessary, the recommendation of the Committee will go forward as a recommendation of the Board.

5. *Attendance.*—Any *ex-officio* Member or Associate Member who is unable to attend a Meeting may depute an Officer to represent him.

Any *ex-officio* Member or Associate Member may, at the direction of the President, bring to a Meeting any assistant who is specially concerned with the business on the Agenda.

Representatives from the Experimental Establishments will attend as required by the President.

6. The Board should collect and index information (or references to where it can be obtained) on all development in engineering and mechanical and physical science that may affect their work. They should also take steps to obtain through Director of Military Intelligence, War Office, for questions outside the British Empire, information on technical subjects (*e.g.*, bridges, water supply, geology, local resources of engineering material, etc.) in all probable theatres of war.

7. Questions for investigation or opinion may be referred to the Board by any Director of the War Office direct. Such questions may also be referred by any other Government Departments having *liaison* Associate Members. The Board may communicate and report directly to the authority who made the reference, but a copy of the final report should be sent to the Director of Fortifications and Works.

8. *Inventions and Proposals from outside sources.*—The Secretary will inform all persons (other than those officially connected with the Board) communicating directly with the Board on the subject of new propositions and inventions, that their applications must, in the first instance, be addressed to the Secretary of the War Office. This applies also to designs submitted by outside inventors.

Before considering any inventions, designs, etc., emanating from outside inventors, the Secretary should see that the papers are referred to the Director of Artillery (A. 4) for record and the appropriate initial action.

All questions relating to the terms for the use of any inventions, patents, designs, etc., will be referred to the Director of Artillery (A. 4).

9. The Board may correspond direct with any branch of the War Office, Admiralty, Air Ministry, or any Establishment having a representative on the Board as Member or Associate Member. Should the Board desire to correspond with Scientific bodies, private manufacturing firms or private individuals in foreign countries upon any subject, the Director of Military Intelligence, War Office, must be consulted in order that the nature of the enquiry being made shall not clash with the policy of the General Staff in regard to the foreign country in which the addressee is situated.

10. *Attendance at Experiments and outside Meetings.*—Members and Associate Members will attend experiments or visit Experimental Establishments at the direction of the President.

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They should be accompanied when possible by representatives of the branch of the General Staff concerned.

11. Members of the Board should take every opportunity of attending meetings of the Engineering Institutions and Scientific Societies dealing with the branches with which they are concerned, and should so far as possible be in personal touch with the leaders in the Civil Engineering and Scientific work.

12. *Reports, etc.*—The President will cause to be prepared and printed half-yearly extracts from the Board's proceedings showing the action taken in the various enquiries on which the Board has been engaged during the preceding six months. These should be circulated to all Chief Engineers, Commanding Royal Engineers, Educational Establishments, Government Departments and Branches interested. The circulation lists to be submitted to the Director of Fortifications and Works for approval.

Where work which is of value for commercial or scientific purposes has been carried out for the Board an account of such work should be published, provided it is not considered necessary in any case to keep the results confidential for reasons of State. Recommendations for the matter to be published and the manner of publication should be forwarded to the Director of Fortifications and Works. Copies of reports dealing with subjects concerning foreign countries should be passed to the Director of Military Intelligence as soon as possible, for any remarks he may care to make, before being circulated to Officers, Departments and Branches interested.

The President will forward monthly a brief summary of the progress for the information of the Director of Fortifications and Works.

A brief monthly summary of experiments will be circulated to all Chief Engineers and interested Government Departments for the early dissemination of results obtained.

13. *Experimental Establishments.*—The undermentioned Experimental Establishments will be under the direct control of the Board as regards all experimental work carried out by them—

(i.) Signals-Experimental Establishment (Woolwich).
(ii.) Searchlight Experimental Establishment (London).
(iii.) Camouflage Experimental Establishment (Salisbury Plain).
(iv.) Experimental Bridging Company, R.E. (Christchurch).
(v.) Experimental Section, R.E. (School of Military Engineering).

14. *Additional or Expert Assistance.*—The Board is empowered to arrange for the attendance of Civilian Experts at any meeting, or to ask for their opinion on any matter before the Board. In such cases the payment of fees is authorized.

HUME REINFORCED CONCRETE PIPES.

THE process of manufacture of these pipes is the invention of Mr. W. R. Hume, of Adelaide, S. Australia.

The reinforcement consists of any suitable wire spirally wound on a revolving cylinder of the same diameter as the inside of the required pipe. The strength and amount of wire varies with the pressure that the pipe is required to withstand.

This wire reinforcement—removed from the cylinder—is placed inside another cylinder formed of 1/16-in. steel-plate which is supported horizontally in a casting-machine, on friction rollers. Flanges, with their centres drilled to correspond with the desired internal diameter of the pipe, are fitted to the end of this cylinder.

The mould thus formed, together with the reinforcement, is slowly revolved while the requisite quantity of wet concrete is introduced from one or both ends. The mixture is at the same time automatically distributed by centrifugal action evenly along the whole length of the mould, and completely embeds the reinforcement. No internal shuttering is required.

The velocity of rotation is then increased, causing the concrete

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to spread itself outward under very great pressure. In a few minutes, excess of water in the mixture is expelled under this compression from the mass of concrete into the hollow of the pipe—from whence it drains when rotation ceases. The inner surface of the pipe so produced is polished, during subsequent rotation of the machine, by a round steel-rod resting on the inner circumference of the flanges. The time required for revolving the pipe ranges from 6 minutes for a pipe of 4-in. diameter, to 20 minutes for one of 48-in. diameter. At the end of this time the mould containing the pipe is rolled off the machine into a steaming-chamber where it lies for 24 hours. It is then opened, and the pipe is put to season for a month under cover, or in water tanks.

The flanges leave V-shaped circular depressions in the ends of the pipes which, when butted, are filled with plastic bituminous cement. The joints are covered by 6-in. reinforced concrete collars—made in the same manner as the pipes—held in position by cement backing.

The invention admits of manufacture of concrete pipes of perfect uniformity and density of structure. They can be produced at great speed and may be used with especial advantage for long lines in open country.

Since the aggregate is usually composed of local materials the cost of such pipe lines is very considerably less than for similar lines of cast-iron or steel.

They are stated to be impervious at high pressures. Excess of pressure is invariably accompanied by sweating and seepage, a fracture or burst is therefore unlikely to occur without warning.

The pipes are reported to have been subjected to pressure heads up to 900 ft., but no completed pipe line is as yet at work under a greater head than 400 ft. It is understood that tenders for pipes up to 8-ft. diameter have been submitted. At present the sizes manufactured range between 4 and 60 in., in 6 or 8 ft. lengths. They are constructed to meet working pressures up to 100 lbs. per sq. in. The pipes are said to be very largely used in water-supply and irrigation projects in Australia, and applications of the process to the production of telegraph poles, piles, columns, concrete blocks, and pipes of oviform section have given satisfactory results. It is stated that a cubic foot of two to one concrete packed centrifugally is some six pounds heavier than an equal quantity of the same aggregate mixed in the ordinary way.

A very full account (illustrated) of the process appeared in the current year's March–April number of the *Journal of Industries*, pp. 224–235.

The process is also described in the following Journals :—*Engineering News-Record*, Vol. 83, No. 15, pp. 707–708 ; *Journal of South African Institution of Engineers*, May, 1920, pp. 175–184, and Sept., 1920, pp. 28–29.

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REVIEWS.

ENGINEERING CONSTRUCTION (2 Vols.).

By W. H. WARREN. (Published by Longmans & Co., 1921, price 66s.).

This treatise was first published in 1894 and dealt in a thorough manner with construction in iron, steel and timber, and has since been revised and enlarged several times. The edition under review is in two volumes, which can be bought separately, the first dealing with steel and timber structures and the second with masonry and concrete. Volume I. has been brought thoroughly up to date and now comprises in a comparatively small space a complete text book on modern practice in steel construction, together with several chapters on heavy timber structures. The physical properties and testing of the materials are very completely dealt with, and the principles and formulæ involved in their use are fully explained. Several of the simpler types of steel bridges are worked out in detail, and the methods involved in the design of large steel arches, swinging and suspension bridges are considered at length. Volume II. deals with all kinds of masonry from an engineering point of view, including a thorough treatment of reinforced concrete. The chapters on the properties, manufacture and testing of the materials are very useful, and those on stress computation and design of dams, retaining walls, foundations, etc., are up to date.

Generally speaking the book comprises the most modern methods of treatment of engineering construction in all parts of the world, and, although necessarily somewhat condensed in parts, omits nothing of importance. To those wishing for an up-to-date work covering a very large field in a comparatively small space this book can be thoroughly recommended.

E.F.T.

A NOTE ON THE THEORY OF THE THERMIONIC TUBE.

By DR. J. A. FLEMING, D.SC., F.R.S.

Dr. J. A. Fleming, F.R.S., has kindly sent a copy of his note on the Theory of the Thermionic Tube, and the following extract may be of interest to those interested in Physics and Mathematics.

The case is considered of a hot wire cross-section radius (a) placed in the axis of a cylindrical anode radius R, which is at potential V_0.

V is potential at a distance (r) from centre of wire, ρ is density of space charge at that point and v is velocity of the electrons.

Then the thermionic current is given by

$$i = -2\pi r \rho v \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

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From which it follows that

$$eV = \tfrac{1}{2} mv^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Where e and m are the charge and mass of an electron provided it is assumed that

(a). The electrons are emitted from the cathode without initial velocity.

(b). The cathode is all at zero potential.

From (1) and (2) it follows

$$v = \sqrt{\frac{2e}{m}} \cdot \sqrt{V} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3).$$

Poissons Equation gives

$$\frac{d^2V}{dr^2} + \frac{1}{r}\frac{dV}{dr} = -4\pi\rho \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4).$$

From which by application of equations (1) and (3) it follows that

$$r\frac{d^2V}{dr^2} + \frac{dV}{dr} = \frac{1}{\sqrt{V}} \times 2i\sqrt{\frac{m}{2e}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Dr. Fleming shows that this equation can be solved by assuming that $V = r^n \phi(r)$ where $\phi(r)$ is some function of the form $\phi(r) = \beta^m K$ where K is a constant.

The solution given by Dr. Fleming is

$$i = \frac{2}{9}\sqrt{\frac{2e}{m}}\left(\frac{V^{\frac{3}{2}}}{r\beta^2}\right)$$

Where

$$\beta = \log\frac{r}{a} - \frac{2}{5}\left(\log\frac{r}{a}\right)^2 + \frac{11}{120}\left(\log\frac{r}{a}\right)^3 - \frac{47}{3300}\left(\log\frac{r}{a}\right)^4, \text{ etc.}$$

J. M. WADE, *Lieut.-Colonel.*

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 38.—*Official Announcements.*—Any soldiers, officials or workmen in army employment who were entitled to vote in the Upper Silesian plebiscite, were given an advance up to two weeks' wages, not exceeding 500 marks, towards their travelling expenses. Repayments to be made at 50 marks a month.

No. 39.—*A French View of Field-Marshal von Hindenburg.*—General von Kuhl, who was C.G.S. to von Kluck at the beginning of the war, reviews General Buat's book, and finds it, on the whole, very just. He replies to General Buat's criticism, that the Germans should not, in the spring of 1918, have tried for a decision before they had drawn all the hostile reserves, by saying that the Germans had insufficient resources to do this. They had to rely on the quality of their troops and the care with which their arrangements were made, to enable them to reach their objectives. General von Kuhl says that the fact that

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these objectives were so nearly attained, is proof that their trust was not misplaced and that their calculations were very nearly correct. Buat's opinion of Ludendorff is much appreciated, but von Kuhl cannot agree that he did everything and that Hindenburg was only a figure-head.

A New Form of Taxation.—A proposal has been put up to the Hungarian parliament for the taxation of all who did not serve at the front during the war. According to the proposal any man, whether fit or not, born between 1868 and 1899, must show service, if not in the front line, at any rate in the front area, or else pay up to three times his income-tax and twenty times his property tax ! If several members of a family avoided being sent to the front, the tax is to be increased fifty per cent. Employers, who succeeded in getting their employees exempted, are to pay up to 2,000 kroner for each man. The proceeds, which are expected to amount to 300 million kroner, are to be used to help war widows and orphans.

An Austrian Court-Martial.—The following verbatim account of an incident at an Austrian court-martial, held recently in Vienna, illustrates the soldiers' council régime.

The Accused :—I had only had three quarts of wine and about half a dozen pots of beer, up to mid-day.

The Court :—Did you know you were on duty that day ?

Accused :—On pay day I never do any duty ; I get drunk.

Court :—Take him away.

Escort :—We won't have our councillor taken away.

Court :—But why not ? Since he behaves like a drunken swine. (To accused) : Leave the room !

Escort: —None of that ! We're all Christian-socialists here ; besides, we've got our rifles. (Uproar, during which a number of soldiers appear at the windows and applaud the escort.)

No. 40.—*The 42nd French Division at the Battle of the Marne.*—General von Kuhl gives a clear account, from the German side, of this part of the Marne (1914). He says that General d'Esperey (5th Army) on the night of the 8-9th September relieved the 42nd Division, which was Foch's left division, in order to save a complete break through the 9th Army. On relief, the 42nd started on a ten-mile march to Linthelles, behind the right of the 9th Army, and should have arrived at 1 p.m. 9th. It was most urgently needed, but did not arrive till the evening and was then too exhausted to move. General Dubois, commanding the 9th French Corps, ordered a counter-attack to ease the pressure on the rest of the Army, and this counter-attack reached its objectives because, according to von Kuhl, the 3rd German Army had already retired in consequence of the withdrawal of the 2nd (von Bulow's) Army. The counter-attack consequently met with no opposition, according to the German account. On the other hand, the frontispiece of General Dubois' book gives a spirited picture of the " Assault on Mondement on the evening of Sept. 9th." (Whichever may be correct, it is well known now that the 42nd Division never made the attack which has been so widely attributed to it, though it is easy to see how such a story could arise.)

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Tanks.—Lieut.-Colonel Scheunemann is very dubious about the future types of tanks, foreshadowed in a recent number of the *R.E. Journal.* He does not believe that a caterpillar track can stand the speeds indicated, or that a 12-in. mortar could be carried and fired successfully; still less does he believe in the 17-cm. armour plating of the heavy tank. However, he says the article merits careful attention, because it shows new lines of thought.

No. 41.—*The Break-through on the Macedonian Front.*—General von Scholtz, formerly army group commander on the Macedonian front, declares that the front could quite well have been held, if the Bulgarians had behaved reasonably well. There were plenty of reserves, but they would not fight, and the only part of the front which fought well was that commanded by Basov and Neresov, opposite the British. He says that G.H.Q. is blamed for two things; first for not attacking the allied right, on the Struma, when this had been stripped of all its reserves for the main attack, and secondly, for waiting too long before ordering the retreat of the western sector of the 11th Army. As regards the first, he says that the Bulgarian Army on the Struma front was not under him, but under the Bulgars; and besides, it was far too weak, morally and materially. The delay in withdrawing the western front was due to the fact that it formed the link with the Austrian troops in Albania. Even so, however, if Bulgaria had not capitulated these troops would probably have been able to effect their junction with the German and Austrian re-inforcements coming down from the north. General Scholtz declares that even after three years of consideration he cannot see that he could have done more than he did. If troops will not fight, no one can win battles with them. He notes that all the Germans, chiefly artillery, machine-gun and technical troops, did splendidly and showed none of the signs of disintegration which were, at that time, beginning to appear on the western front.

The Value of French and British Military Histories of the Great War.—The writer solemnly warns both French and British historians that, so long as they fail to lift up their voices in protest against the trial of war-criminals, so long German readers will refuse to believe what they write! Though our historians may perhaps fail to follow the argument, they will doubtless tremble at the threat.

No. 42.—*The Military and Political Situation in the World.*—The writer notes with satisfaction that the Reichswehr will, for the future, be beyond the reach of political influence. Exact limits have been laid down to define the unions and associations to which officers and men may or may not belong, and some of the hitherto best-known ones are now forbidden. The remainder of the article consists of the usual complaints about Upper Silesia, the indemnity, the size of the French Army and the hard heart of General Nollet, head of the inter-allied mission of control.

1914—*Near Paris.*—The writer describes his adventures on the 9th and 10th September, 1914. He was commanding a company in the 43rd Reserve Infantry Brigade, which was right flank guard of the 1st Army. The orders for the retreat failed to reach him and for some 24 hours he was completely surrounded by French cavalry. Eventually he got away, very tired, but proud of the fact that his was the unit

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which reached furthest south. He says he saw the Eiffel Tower from the church of the village of Montagny St. Felicité.

No. 43.—*General von Prittwitz after the Battle of Gumbinnen on 20th August*, 1914.—General Reitzenstein contributes an article which, if correct, rather upsets the ideas hitherto held regarding the situation in East Prussia during the latter half of August, 1914. He says it is generally believed that General Prittwitz, who commanded the 8th Army, consisting of nine Divisions and the equivalent of four Landwehr Divisions, decided, on the evening of the 20th August, after the battle of Gumbinnen, to evacuate East and West Prussia and retire to the left bank of the Vistula. G.H.Q. apparently also believed this to be his intention, and did not agree with it. They accordingly relieved Prittwitz of his command, replacing him with Hindenburg, with Ludendorff as Chief of Staff, on 23rd August. (It may be noted that Prittwitz's alleged plan, to retire behind the Vistula, leaving Königsberg to hold out, was in agreement with the Schlieffen scheme. Hypotheses, though futile, are alluring. What would have been the result of the battle of the Marne, if G.H.Q. had decided to adhere to Schlieffen's plan and in consequence had not thought it necessary to withdraw two Corps from France, to reinforce East Prussia?) G.H.Q., on the evening of the 22nd, ordered the 8th Army to advance against the Russian Narew Army, under Samsonoff (10 Divisions). This involved leaving the Niemen army (24 Divisions) under Rennenkampf, practically unopposed. Von Prittwitz always asserted, verbally and in writing, that he had no intention of withdrawing to the Vistula, and intended, after the war, to publish his defence. Before he could do so he died, leaving to General Reitzenstein his papers, which include an autograph report to G.H.Q. written on the 21st August, copied during the night of 21st-22nd and despatched on 22nd, on the very day when he received his recall. The report, after describing the battle of Gumbinnen, says the situation is bad in the centre but good on each flank, and continues: "During the situation I have depicted which, in spite of the losses of the 17th Corps, was not unfavourable, an aeroplane report arrived, stating, with the greatest distinctness, that the enemy was advancing in three columns, from the Narew and from the direction of Warsaw. The heads of the two leading columns had reached the German frontier north-west of Mlawa. I had, then, to decide whether to renew the very promising fight, in which I had been hitherto engaged, or to content myself with the success already gained, block the defiles between the lakes and turn against this new enemy. I decided on the latter . . . because, although I could have given Rennenkampf a heavy blow, if he had stood, on the other hand the Narew Army would have gained an extremely valuable day. . . . To carry out my plan, it has been necessary to set the Army in motion towards its right flank, as quickly as possible. The 1st Corps has moved to Insterburg with a view to transport thence, by rail, to Gosslershausen and Bischofswerder. The transport begins on the 22nd. Detrainment should be finished on the 25th and the Corps be ready then to strike the enemy's left flank. 3rd Reserve Division and 6th Landwehr Brigade to detrain at Allenstein and come under 20th Corps. 1st Reserve Corps and 17th Corps reach Nordenburg and Astrawischken to-day (22. 8)

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and move on *via* Gerdauen and Allenburg." So much for von Prittwitz's report. Whether it was right or wrong to leave Rennenkampf's (Niemen) Army and turn against Samsonoff, is not the question. What is clear, is that Prittwitz not only intended to attack Samsonoff, but also had actually started on 21st August the necessary movements to enable him to do so. Whether, without these preparations, the battle of Tannenberg could have been fought or not, cannot be definitely stated, but it seems clear that there was never any intention to withdraw behind the Vistula. The report does not even mention the name, and von Prittwitz could never understand how his intentions came to be so misrepresented. His staff knew all about them, for one of them wrote to him after Tannenberg and said, " It must be a great satisfaction to you that your plans, for operations against the Narew Army, have now had such brilliant success. Certainly they were carried out with remarkable energy, but victory could never have been attained unless the move of the 1st Corps had been begun in good time."

In German G.H.Q.—This is the title of a book by the head of the Austro-Hungarian Mission with the German forces. The author describes how the Austrian C.-in-C., Conrad von Hotzendorf, failed to appreciate the situation and blamed the German 8th Army, for not helping to relieve the pressure in Galicia in September, 1914. As the 8th Army not only occupied 12 Russian Corps and very large forces of cavalry, but also thoroughly defeated them, this blame seems rather unjustified, to say the least. When Italy's entry into the war became imminent, Germany begged Austria to ward it off, by conceding Italian demands. This Austria refused to do, apparently saying, " You hold Alsace-Lorraine; why should we not hold some Italian territory? " Perhaps the Austrians did not altogether trust their ally.

No. 44.—*Railway Transport at the Beginning of the War.*—General Baumgarten Crusius blames this somewhat severely in his book *German Leading in the Marne Campaign*, and now is taken to task by Major Kretzschmann. The latter states that on 24th August, 1914, the question of sending corps to Russia from France was first discussed, and the railways at once began their preparations. On 26th August, 1914, the move order was given and on 30th August, 1914, entrainment began. It is impossible without most careful examination to say whether this delay was avoidable or not. Kretzschmann says it was not.

No. 45.—*General von Prittwitz after the Battle of Gumbinnen.*—Lieut.-Colonel von Schäfer disagrees with General Reitzenstein (*vide* No. 43) about General von Prittwitz. He declares that on the 20th August it was von Prittwitz's intention to withdraw, but that in consequence of the communications he received from G.H.Q. and of the clearing up of the situation, by the time he wrote the report given by General Reitzenstein, his views had changed. On the 20th he apparently told Mackensen, on the telephone he was going back, and his intentions were so understood by the L. of C. authorities and others. When, on the 21st, Rennenkampf did not advance, he began to regain confidence, and worked on by G.H.Q., decided on a re-grouping of his army, so as to attack the left flank of the Narew Army.

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Von Schäfer further states that on the evening of the 21st, before von Prittwitz wrote his report, he was speaking to von Stein and von Moltke on the telephone, and that he painted the situation in very gloomy colours and begged for reinforcements. General von Moltke replied that, if he really had to go back, he must at any rate hold the Vistula, at all costs; von Prittwitz said he was doubtful if the "handful of troops" at his disposal would allow him to do so. After this the Kaiser was advised to relieve him of his command.

No. 46.—*Railway Transport at the Beginning of the War.*—General Baumgarten-Crusius and Major Kretzschmann set about each other. General Baumgarten-Crusius declares that three days were lost in entraining the 11th and Guard Reserve Corps at the end of August, 1914; that the whole railway system in the east was bad, until a certain Major Tillmann took charge; and that the use of immature troops for the first Ypres battle was due to the technical railway difficulties which prevented more experienced formations being brought in. Major Kretzschmann says that the loss of three days, from 27th to 30th August, was not due to the railways, but simply to the fact that G.H.Q. did not order the troops to begin to arrive at entraining stations before the 30th; that the improvement in the Eastern railway systems was not due to any individual, but to the belated fulfilment of the demands long urged by the railway authorities, and that the use of young troops at Ypres was not attributable to the inability of the railways to bring up others, but to the loss of time which such a movement, however well carried out, must inevitably entail.

German Artillery in the Break-through Battles.—Colonel Bruchmuller, nicknamed Durchbruchmuller, was the authority most concerned with the organization of the artillery for all the great battles. He has now written a book with the above-mentioned title, which is very well received. He says that during the last 18 months of the war, almost all counter battery work was done with field guns.

The Bolivian Army.—General Hans Kundt has been nominated Chief of Staff to the Bolivian Army. About the year 1900 several German officers were brought in as instructors, but in 1906 a change of government led to their replacement by a French mission. In 1911 another change caused the recall of the Germans with Lieut.-Colonel Kundt at their head. The war caused another break, but he has now gone back, much to the delight, it is said, of the Bolivians.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE GÉNÉRALE.

November, 1920, and January, 1921.

The Revision of the Regulations, and our War Doctrines.—This interesting article, signed "Lucius," commences by pointing out how useful it would be, to those who will be entrusted with the revision of the military regulations, to have for reference a series of considered opinions on the events and lessons of the late war, and calls on every officer who

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was engaged to contribute his impressions, however trivial they may seem to himself. The Minister for War has called for reports from technical commissions of each arm, but for many reasons it is desirable to supplement these by original contributions which would not suffer from the possibly cramping effects of official editing before publication.

The regulations need to be brought up to date for two reasons, one that they do not harmonize with the progress realized during the last six years, and confirmed by experience gained during the war. Many officers consider that the regulations have now no value at all, and ought to be replaced by entirely new ones, but this is only true of the manuals for the different arms; the more general regulations such as the Command of the Higher Formations (*Conduites des Grandes Unités*) and the Field Service Regulations are far from valueless. The second reason is that various instructions published during the war are now themselves out of date, having been based on considerations of the materiel available at the time they were issued, and this materiel has not ceased to improve in number and perfection since those dates. In addition to the work of the technical commissions referred to above, it falls to the High Command to revise the regulations applicable to all arms, which contain matters of principle, and the former can hardly produce useful work until the latter have formulated their doctrines. Again, the latter must be acquainted with the number and composition of the larger formations both in peace and war, which raises the questions of the reorganization of the army, the duration of military service, and general mobilization, considerations to be decided upon by the legislator, and not by the military authority, and outside the scope of this article.

The writer then investigates what he terms the French doctrine of war, without which no troops can be trained. To clear up this question he studies the doctrine prior to 1914, and the modifications suggested by the war. Sufficient indications to form a conception of the former can be gleaned from *La Conduites des Grandes Unités* of 28th October, 1913, from *Le Décret sur le Service des Armées en Campagne* of 2nd December, 1913, and from the Infantry Manœuvre Regulations of 20th April, 1914. Shortly put, the first named inculcates the annihilation of the organized forces of the enemy in as short a time as possible by a decisive battle pushed to the last extremity. The offensive alone leads to positive results, the defensive is vowed to certain defeat. Thus from the strategic point of view operations are conceived of as offensive. But speaking of the Army Corps, the tactical unit, the regulations foresee the case where the situation may necessitate the placing in a state of defence of all or part of the front, with the object of covering a concentration of force before proceeding to attack, or to contain the enemy with reduced effectives so that more troops may be devoted to attack elsewhere. In their turn the Infantry Manœuvre Regulations lay down rules for defence as well as offence. Here it must be noted that the strategic aim of the operations is not in question, with the Army Corps and smaller units the domain of tactics is entered, and the defensive, under the reserves above-named, is admissible. The doctrine therefore was the strategic offensive and the absolute exclusion of the defensive, and a

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tactical offensive with defensive tactics in certain places to favour an offensive elsewhere.

As a practical result of this teaching on the mentality of the officers, in operations of every kind, whether on the map or in the field, there was never any question but of offence and attack. Certainly halts were provided for, as marches cannot be carried on day and night, and then outposts were studied. The delicate question of the retreat was hardly mentioned, was never made the subject of an exercise on the map, still less was it practised in the field. For covering troops only was the problem of defence considered, *i.e.*, the utilization of the ground with a view to holding with a small force an enemy superior in numbers. In consequence, sufficient regard was not paid to the effects of fire, formations were too dense, communications were neglected, and all to hasten the completion of the attack. For the one case in which the regulations permit of a defensive attitude rules are laid down. The Divisional Commander is so to organize his front that it can be held by the smallest possible number of troops, following a definite plan, and carrying it out as far as time admits. Centres of resistance are to be created, to each of which an infantry garrison is told off, artillery positions chosen to flank these centres and fire on the intervals and on possible enemy artillery positions. All troops available after these requirements are met to be held in readiness in rear. The infantry units charged with the defence receive orders as to the task they are to perform, the ground on which the defence is to be organized, the organization to be followed, the material resources placed at their disposal, the position of the command post of the next higher formation, and the communications to be opened with it, and with the neighbouring artillery units. So much for generalities; in regard to some of the details, the ground to be occupied must be reconnoitred, also that which the enemy must traverse, such as points forced on him for the passage of obstacles, hidden approaches, etc., facilities which the ground affords for counter-attack and for a resumption of the offensive. The preparation for the defence comprises organization of the posts to be held by troops, covered communications, telephones, and possibly the preparation of successive lines. The best works are the simplest, those which utilize the accidents of the ground and are difficult for the enemy to locate. Trenches should be deep and narrow, the parapets concealed from view, and dummy trenches should be provided to attract the enemy's fire to localities not occupied. A field of fire must be cleared, distances measured, and machine guns sited so as to flank important posts and to fire on such ground as the enemy may be forced to advance over. Searchlights are installed for night work. A strong and judicious organization permits of a reduction of the troops holding the front, and an augmentation of those held in hand for the counter-attack. In the defence the inviolable rule is to hold on to the end even if it entails complete sacrifice. Infantry act by fire, artillery can intervene by long range fire but must above all reserve the power of firing on the enemy's infantry. Counter-attack troops generally act on a preconceived plan independent of the fortunes of the battle, and resulting from the necessity for using the ground best suited to their action. Kept in hand under cover they attempt to act

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by surprise, and advance resolutely, combining fire and movement. Whether ordered by local or superior command the support of the other arms must be assured to the infantry. Should the enemy obtain a foothold in the line a vigorous offensive return must be undertaken to dislodge him. This brief sketch allows of the statement that, if the principles inculcated were known and intelligently applied, the troops would very quickly adapt themselves to a war of position, but it must be allowed that the rules were not sufficiently widely understood, and in some cases were even ignored.

The instructions relating to the offensive are too long to analyse, and reference will only be made to (1) the importance of the effect of fire, (2) the support of infantry by artillery, (3) the necessity for good communications, and (4) the employment of field works. As to (1) all the regulations draw attention to the increased rapidity of fire, and low trajectory of rifle and gun, and lay down that formations must be flexible and adapted to the ground, that dense formations are too vulnerable, infantry must advance as a line of sharp-shooters, and at a methodical pace allowing of time for reconnaissance before the bulk of the force is engaged. As to (2) the Command of the Larger Formations prescribes the strict and constant co-operation of all arms, that artillery must aid the forward movement of infantry, and prior to the assault must concentrate on all the objectives of the attack. The F.S. Regulations state that until recently it had been agreed that the first duty of the artillery was to silence the enemy guns, and then to riddle with fire the objectives of the infantry attack. It is now recognized that the essential duty of artillery is to support the infantry by destroying whatever causes an obstacle to its progress, and that the only object of destroying the enemy artillery is to ensure the greatest possible vigour being employed against the objectives of the infantry. The preparation of the attack by artillery cannot be carried out independently of the infantry advance, since until the latter commences the enemy remains under cover. Again, the commander is to decide from time to time during the attack the targets for the artillery which will most efficiently aid the infantry advance. (3) The object of communications is to co-ordinate the efforts of all engaged in an operation, and should be established between the commander and his immediate subordinates, between commanders of adjoining sectors, and every subordinate should be in communication with his immediate superior. The command post of the G.O.C. is chosen with a view to rapidity of communication. Telephone and visual signalling are to be established whenever a halt admits of doing so, and with outposts. Stress is also laid on the necessity for close communication between infantry and artillery. All this refers to communication upwards; as to communication downwards, instructions are not so precise, but the Infantry Manœuvre Regulations state that the battalion commander must be in communication with his captains and with the colonel, and frequently with the artillery commander. Communication by aircraft was not foreseen when these regulations were issued. (4) Field fortification is not only foreseen but recommended, light work by infantry alone, and heavier with help from the engineers: 1st to facilitate the advance, 2nd to increase the

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power of resistance of a force momentarily brought to a stand-still, and 3rd to allow a defensive line to utilize the ground to the best advantage. In the offensive ground must never be abandoned; the first troops strive to erect some slight protection, which is improved by successive occupants. If a halt is made by night these works are to be strengthened, and every strong point as it is occupied is to be organized to offer a serious resistance. Works in the defensive have been referred to already, the F.S. Regulations add that edges of localities and woods exposed to enemy artillery fire are to be avoided, but an unexposed edge is a strong point of support. Batteries must be protected by more or less important works, or be sunk entirely underground. Unfortunately field fortification was not made customary, it was urged that a man once under cover would only with difficulty be persuaded to advance again. Also manœuvre grounds could seldom be dug over, and if they could the trouble of refilling trenches was made the excuse for not excavating them. Thus a few exercises as a recruit were all the practice in fortification that a soldier was given.

The allegation that the reverses early in the war were due to faulty principles can now be discussed. There is no fault to find with the strategic principles, but the tactical teaching was perhaps imperfect. Rapidity of movement in the attack, due to a faulty estimate of the effect of fire, was too much insisted upon, hence attacks were at times undertaken with too little consideration, often disconnectedly, and sacrificing all to rapidity of execution. Formations were too dense, and artillery support insufficient, partly owing to want of effective inter-communication. There was a general inaptitude for, and repugnance to, the use of field fortification. Still the regulations distinctly foreshadow a delay amounting to days in completing an attack, and point out that a definite result may often be reached only by capturing several intermediate objectives. However, trench warfare was certainly not foreseen; it was forced on both sides by the peculiar circumstances of the moment. The initial reverses, therefore, cannot be ascribed to the strategic or tactical principles advocated, but to circumstances of which the violation of the neutrality of Belgium is the most important. Still the losses might have been lessened had a thorough grasp of the spirit of the regulations been more general. One excuse is that the Infantry Manœuvre Regulations were not issued until 20th April, 1914, and another is the perhaps excessive initiative to which the infantry had become habituated under the preceding regulations. This section of the article concludes with some words in praise of the training and general aptitude of the officers of the General Staff.

After five years of war against the most redoubtable of adversaries the French war doctrine can be based on the lessons of experience, and a rapid review of the principal events of the war enables the evolution of ideas, as new problems presented themselves, to be followed. To facilitate the study the operations are divided into 7 periods, (1) from August to 13th September, 1914, *Open warfare*, (2) 13th September to 16th November, 1914, *End of open and commencement of trench warfare*, (3) winter 1914–15 and year 1915, *The first attempts to penetrate the enemy's front*, (4) years 1916 and 1917 up to 16th April, *The German offensive at*

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Verdun and the Allied offensives on the Somme, in Artois, and on the Aisne, (5) June to December, 1917, *Attacks with limited objectives,* (6) spring of 1918, *The great German offensive and re-appearance of open warfare,* (7) July to November, 1918, *The French counter-offensive and the general Allied offensive.*

In the first period events occurred as foreshadowed by the *Conduites des Grandes Unités,* which says that "the general engagement is the resultant of battles of armies more or less distinct from each other, but connected by one and the same aim." Thus the threat of envelopment by the Germans of the French left wing led to a retirement of the whole Allied force, and reciprocally a manœuvre of the same nature led to the retirement of the enemy at the Marne. Events in the first period also bring out, both from the strategic and tactical stand-points, the importance of certain recognized factors of success. From the strategical stand-point (1st) the value of suprise. The French anticipated only being opposed by 20 Army Corps and 8 divisions of cavalry, but contrary to expectation the Germans employed for the first shock 13 reserve Corps, thus being able to increase their right wing to 16 Corps instead of the anticipated 8. The movement through Belgium was foreseen, but was a surprise to the extent that it was not expected that the force on this flank would be so large and composed of the best troops at the enemy's disposition, nor that it would take the offensive before the French left was completely concentrated. One surprise for the Germans was the fact that the Russians were ready to take the field at the commencement of the war instead of two months later as had been expected, another was the entry of Great Britain into the war, a third the Allied stand on the Marne, and lastly Maunoury's attack on their right flank just as they were daring all to envelope the French left. (2nd) The general adoption of the enveloping movement. The German plan was to envelope both wings; their left was stopped by the frontier fortifications, their right almost succeeded. The victory on the Marne was due to a similar manœuvre, and so long as the fronts are not brought to an absolute standstill it is from an enveloping attack that each side will seek a decision. In none of these cases was the envelopment complete enough to lead to the annihiliation of the opponent, it only amounted to an outflanking movement, and envelopment was avoided in each case by the retreat of the wing attacked. For success, provided that the menaced force has not lost its *morale,* it must either be ignorant of its danger, or be so tightly held that it cannot withdraw in time, and the latter assumes a preponderating force on the side of the attacker. (3rd) The importance of *morale.* This is evidenced by the battle of the Marne, where, in spite of a retreat amounting to 300 kilometres on the extreme left of the Allies, the spirit of the troops was so maintained that when the time came for the promised advance all fatigue was forgotten, and faith in success and confidence in their leaders enabled the attack to be carried out with dash and ardour. (4th) The lack of co-ordination in the operations of the Allied armies, due to the absence of one controlling mind and unity of action.

A. R. REYNOLDS.

(To be continued).

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CONTOURING BY THE STEREOSCOPE ON AIR PHOTOS.

By MAJOR AND BT. LIEUT.-COLONEL S. F. NEWCOMBE, D.S.O., R.E.

SOME experiments have been made with Thompson's Stereoplotter on air photos with successful results. Given ordinarily good conditions, it should be possible to measure differences of height to within 5 ft. to 10 ft. of accuracy, and, provided certain fixed heights are available, as part of the trig. survey, it should be possible to draw contours to say 10 ft. accuracy and to show the shape of the ground extremely well, by combining contours with shading.

A description of Thompson's Stereoplotter is given in the *Geographical Journal* of May, 1908.

For the present purpose, one need only describe the stereo microscope with a hair line in the centre of the glass which can be used as an indicator. The plotter is not used.

The photos, half-plate, are placed in two holders on a frame which can be moved from right to left or vice versa. The two photos are directly under two prisms one foot apart, which deflect the rays into the microscopes or eyepieces. Thus the base of the stereoscope is 1 ft. The stereoscope has a motion up and down the vertical lines of the photos at right angles to the horizontal motion of the photos.

The left negative can be moved right and left, independently of the other, by means of a slow motion screw which records on a drum the distance moved.

The total movement of the left photo on the particular instrument used is only 2 in. One complete turn of the drum measured ·1 in. on the photo. Movements of ·001 in. can be easily measured.

It is well to have certain definitions for clearness. A negative is said to be horizontal when it has been taken (or has been mechanically corrected to be) absolutely parallel to a flat earth surface.

The optical centre, O, is the point obtained on any negative at the intersection of the lines joining the collimating marks on the middle points of the edges.

The vertical centre, V, is the point on the negative where the perpendicular from the centre of the lens to the earth's surface cuts the negative. Thus in negative HK, having tilt α to the earth's surface, CLV is perpendicular to the earth, V is the vertical centre, O is the optical centre of the negative, given by joining the collimating points, and BLO is perpendicular to HK.

VO=LO . tan VLO=focal length $\times$ tan α (tilt), and VO is measured along the prime vert.

The horizontal line of a negative is a line through the optical

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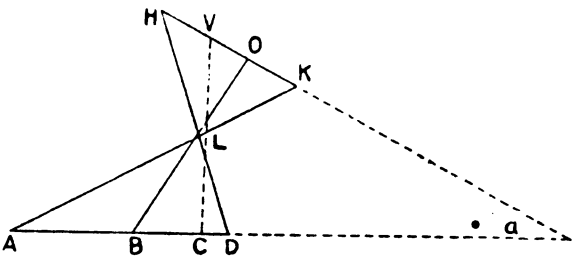
centre O, parallel to the line made by the plane of the negative with the horizontal earth plane.



The prime vertical is a line in the negative at right angles to the horizontal line through O, the optical centre. Thus a horizontal negative has no prime vertical or horizontal line.

To use two overlapping photos under the stereoplotter, the following steps are necessary :—

(1) Enlarge both negatives to fit trig. points, to get rid of tilt and make the enlargements exactly the same scale.
(2) Find the vertical centre of each negative.
(3) Mark on each negative the line joining these two vertical centres.
(4) Reduce these enlargements on to two half-plate positives, keeping the line joining the vertical centres horizontally along the centres of the plates, parallel to the longer side.
(5) Insert these positives in the frames under the stereoscope.
(6) Adjust the positives by the slow motion screws until they become absolutely parallel. This can be seen through the stereoscope by moving the microscopes over each corner of both positives, and seeing that the verticals or hairs in the microscopes cover the same vertical position over each negative. They will not cover the same horizontal position, if of unequal height, unless parallax is adjusted by the spiral drum. To do this adjustment for parallax, turn the drum to infinity and then bring the vertical centres of both negatives together under the indices in the eye-pieces. Suppose the reading to be 1·4 in. or 14 turns of the drum. Then move the stereoscope over various points over the positives, recording the readings on the drum.

It is useful to have a bromide enlargement to assist one in realizing the country as shown on the photo, and one can mark on this photo each point as it is observed.

In the experiment tried with some overlapping photos of hills near Cairo (see *Plate*), the scale of the original negatives was 1/4800

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measured by comparing certain distances on the photo with the 1/5000 map (uncontoured) of Cairo.

The distance between the vertical centres VaVb measured 1·25 in. Hence the base was $4800 \times 1{\cdot}25$ in. $=500$ ft.

The focal length of the lens was 6 in.

The height at which the photos were taken (assuming Va and Vb to be the same height) can be determined (*a*) by the formula $h=f/\text{scale}$, thus 6 in. divided by 1/4800, and checked by (*b*) measuring a known height on the two negatives of a tower, say 100 ft. high, the reading on the drum being ·1.

$$\text{Height of plane} = f \text{. base}/{\cdot}1 - 100$$
$$= {\cdot}5 \times 500/{\cdot}1 - 100$$
$$= 2400.$$

So far, except for this last check, the work has been independent of the stereoscope.

In the experiment the base measured 1·4 in. instead of 1·25 in. since the original negative had been enlarged. This is equivalent to having a focal length of $6 \times 14/12{\cdot}5$ (or 6·72).

Suppose the height of the point Va on the map to be 100 ft., and the vertical hairs on the stereoscope coincide when bringing Va on each plate directly under them reading 1·4 in. on the drum. Move the stereoscope over the plates and wherever the vertical hairs coincide on the same point, on either plate, while reading 1·4 in., such points will also be 100 ft. high. Where points are not 100 ft. high, the hairs will not coincide. It will be necessary then to move the left plate through a certain distance till the point A on both plates coincides, giving a reading of say 1·39 in. on the drum. This distance ·01 in. is the parallax.

As shown in Capt. Thompson's article in the *G.J.* of May, 1908—

$$\text{Parallax} = f \times \text{base/height},$$

or

$$\text{Height} = f \times \text{base/parallax}.$$

$$f = 6{\cdot}72, \text{ base} = 500, \text{ parallax} = 1{\cdot}39,$$
$$\text{Height} = 6{\cdot}72 \times 500/1{\cdot}39 = 2417 \text{ ft.}$$

i.e., A is 2417 ft. below the aeroplane when the photo was taken or 17 ft. below the plane of the trig. points.

So with the other points,

$$6{\cdot}72 \times 500/1{\cdot}415 = 2374{\cdot}5$$

and

$$6{\cdot}72 \times 500/1{\cdot}420 = 2366{\cdot}2$$

and

$$6{\cdot}72 \times 500/1{\cdot}375 = 2443{\cdot}6$$

and since the height of the aeroplane was 2400 above the flat plane of the trig. points, we have,

1st	point	dist.	below	aeroplane	2417·0	ht.	refd.	to	trig. pts. $-17{\cdot}0$
2nd	,,	,,	,,	,,	2374·5	,,	,,	,,	,, $+25{\cdot}5$
3rd	,,	,,	,,	,,	2366·2	,,	,,	,,	,, $+33{\cdot}8$
4th	,,	,,	,,	,,	2443·6	,,	,,	,,	,, $-43{\cdot}6$

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Having obtained various heights over the photos, it is extremely easy to put in the contours, taking more height when necessary and viewing the photos stereoscopically to see the shape of the ground, though the light and shade of the bromide is an almost sufficient indication. The photos touched up, with the contours drawn on, make the hilly grounds stand out more truly and more vividly than any contoured map or any map shaded by a draughtsman who has never seen the original country.

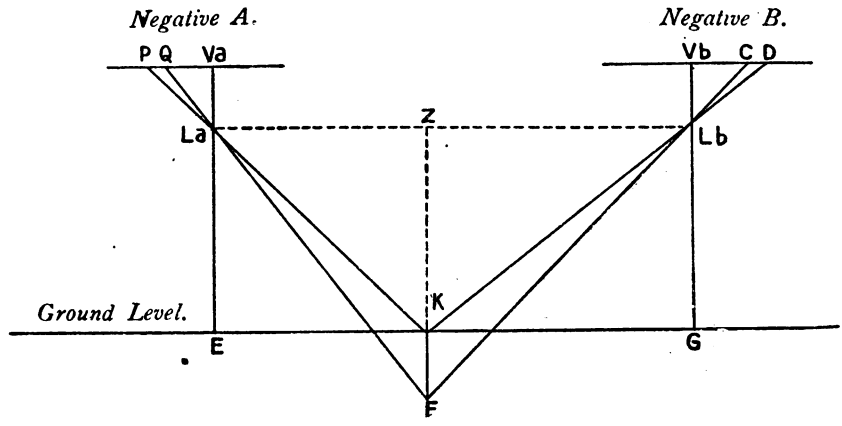
It must be noted in the above example that the negatives used were supposed to be absolutely corrected for tilt, by enlarging them to fit trig. points all of the same level and lying in one horizontal plane. The base is the distance between the two vertical centres (*vide* definitions). Hence the vertical centres must be found; the distance between them can be measured either by piecing the two photos together and measuring them off according to the scale of the photo, or by measuring the distance on the drum. The scale of course is known by referring the trig. points on the photo to those on the map. The formula

$$\text{Height of aeroplane} = \text{focal length} \times \text{base/parallax}$$

is adapted from Thompson's article. We require, however, the height above or below the level of the trig. points. This formula is,

$$h = \text{focal length} \times \text{base/parallax} - \text{height of aeroplane.}$$

Now whether the photos be originally taken at a tilt or not, the parallax measurement would not vary, but one cannot get the base correctly measured unless tilt is corrected and one can measure the distance between the vertical (and not optical) centres. Suppose the two photos to be taken at different heights, it would (very slightly) affect the parallax measurement, but as flying would be 10,000, say, and differences only 100 ft. or so, the error would not be of importance, especially as both photos are brought to the same scale to fit the trig. points. Further, since during the trig. work,



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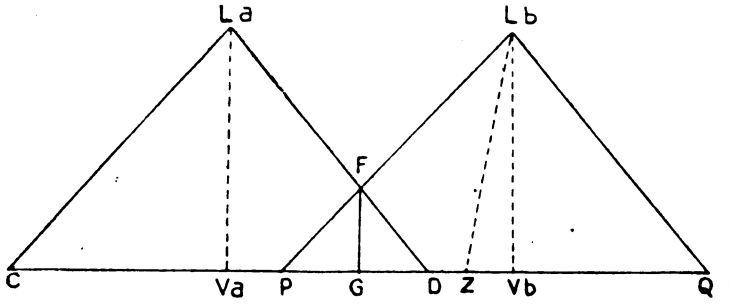
certain heights will be determined, should any error be perceptible, it can be quickly checked and distributed between these points.

Given then the assumption that the photos are made to fit the trig. points and vertical centres are found, the use of the stereoscope for contouring seems eminently practical and accurate for general purposes to say 1/5000 scale, or at least 1/10000 scale.

In above figure let PQVa, DCVb be two negatives, La and Lb the lenses, and EKG the horizontal ground. Let F be a point below K.

Then ELa=height of plane=2400 ft. LV=focal length 6 in.

Parallax of K=PV+DV Depth $FK=\frac{f\times \text{base (LaLb)}}{QVa+CVb}-ELa.$



In above figure, if CD, PQ represent areas covered by two lenses La and Lb and FG be a tower, provided La Lb be known, (or Va Vb), and PD the parallax is measured on the stereoscope, the height FG can be determined.

Suppose one negative is tilted, and hence the vertical centre Vb is thrown out by 2° to Z,

Then ZV=LV . tan 2° or 1/30 height of plane.

PD is not altered by the tilt, but the base Va Vb is largely altered by this 2° tilt. Hence the importance of getting the vertical centre.

Suppose now that one photo is taken at 10,000 ft. and the next at 10,050 ft.

Then if f=12 in., base=2,000 ft., and height=10,000 ft., the reading 2·4 in. on the drum represents the distance between two vertical centres, and for every ·01 in. reading on the drum, the

$$\text{Height}=\frac{12\times 2000}{2\cdot 41}-H=41\cdot 494 \text{ ft.}$$

If the height be 10,050 ft., the reading on the drum is 2·388 with the base of 2,000 ft., and for every ·01 in. reading on the drum, the

$$\text{Height}=\frac{12\times 2000}{2\cdot 398}-H=41\cdot 660.$$

Hence a reading of ·01 in. on the drum reads only ·17 ft. difference with these differences of height.

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ADJUSTMENT OF AIRPHOTOS TO FIXED POINTS OF UNEQUAL HEIGHTS.

If the trig. points are not of the same height, one must find a plane which passes through three of these points.

Suppose A and B to be of the same height and C of different height. This is the simplest case. Then AB will be the horizontal line, and the inclination of the plane ABC to the horizontal can easily be calculated by drawing a line CD from C to AB.

Then $$\sin \alpha = \frac{\text{height of C}}{\text{CD}}$$

If A, B are unequal heights, the locus of the plane can be found, that is, its angle of tilt to the horizontal; and also the horizontal line through A, *i.e.*, the line where the plane ABC joins the horizontal plane through A.

In practice, (1) Plot A, B, C, in the plane inclined at angle α to horizontal, on a given scale. Assuming that the tilt of the negative is not excessive, make the three points P, Q, R, in the negative corresponding to A, B, C, and fit them on the plotted diagram. This can be done with the enlarging camera, just the same as getting rid of tilt to fit trig. points on a horizontal plane.

If we place a plane AED passing through the horizontal line through A and making an angle α with the plane ABC, and remove the plane ABC, the negative will be projected correctly on to the horizontal plane, which AED represents. It would not be the required scale, nor probably in focus, but any points A, E, D, F, lying in the horizontal plane of the earth, would be correctly and proportionately represented.

The high points, C and B, which we might suppose to be tops of towers, would be thrown out of position according to parallax, or according to the angle they subtend at the lens with the perpendicular from the lens to the earth: the feet of these towers would be correctly represented, if visible. Hence on any one photo it is obvious that uneven ground can never be to scale.

But by using overlapping photos corrected to the horizontal, one can correct, by the stereoscope, the positions of C, B, etc., which are out of the horizontal, and plot them in their correct position.

To preserve focus, one would enlarge the photo PQR to fit the points ABC: and then, with that enlargement, make a photo of equal size through the enlarging camera, and give a tilt of α to the photo ABC and α to the screen AED.

In the attached figure, let ABC be three trig. points of unequal height. The plane ABC is found to pass through these three points making an angle α with the horizontal plane AD.

The negative QRP which had a small tilt in any direction has been made to fit parallel to the plane ABC, and the points PQR to fit the points CAB on the map by the enlarging camera. Draw

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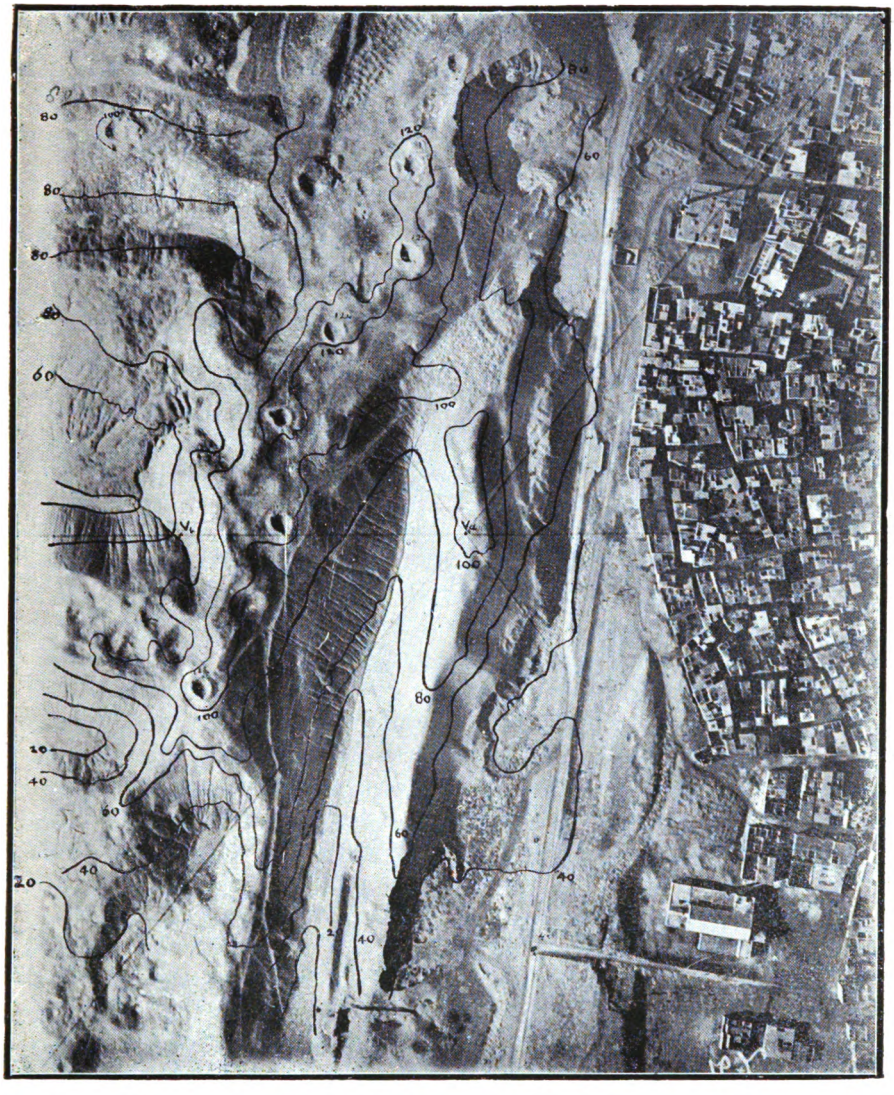
CONTOURING BY THE STEREOSCOPE ON AIR PHOTOS.



Map of Hills on East edge of Cairo roughly contoured by the Stereoscope from 2 overlapping air photos.
The contours have not been checked, and no true heights were obtained.
The intervals between the contours should be found to be consistent, and generally they should describe the ground.

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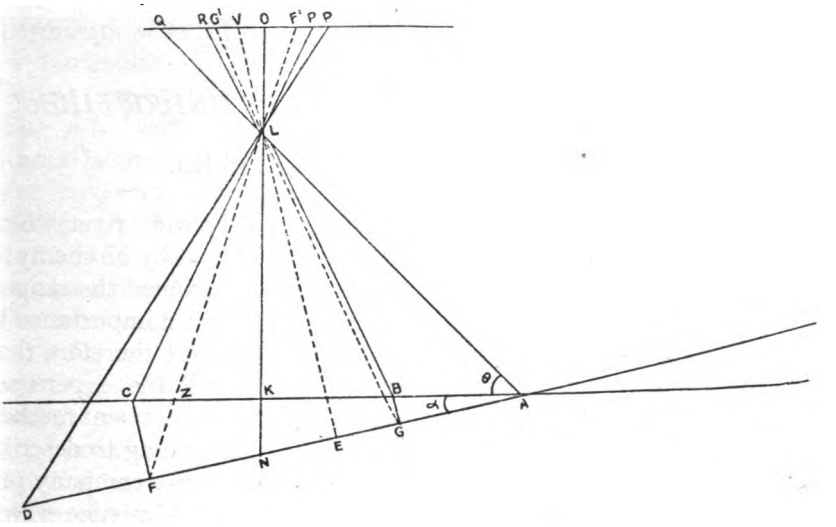
OLKN perpendicular to QP and CA. Then O is the optical centre of the negative in its present position and if ELV is perpendicular to AD, V is the vertical centre.



$$OV = LO \tan \alpha = f \cdot \tan \alpha.$$

Draw CF, BG to AD; let them represent two towers, C and B the tops, trig. stations, F and G the feet in the horizontal plane AD.

Join FL, GL, cutting the negative in F^1, G^1.

Then F^1, G^1 represent the feet of these towers on the photo.

Hence, if the positions F^1, G^1 are calculated and marked, and if B, C are plotted as usual and reduced to the horizontal plane, the photo QRP can be tilted through the angle α, so that QF^1G^1 fit the positions ABC reduced to the horizontal plane.

Provided the optical centre O can be found, OQ can be measured, and LO=focal length; hence angle QLO is known and angle CAL. There are enough known angles and lengths to calculate F^1P and RG^1.

Hence, diagrammetically or mathematically, the photo can be reduced to fit three trig. points of unequal height and reduced again to the horizontal plane.

In the final map, it is obvious that the only points correct to scale are those of the same level as A (except the point under the vertical centre).

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EXPEDIENT FOR CROSSING RIVERS UNDER FIRE.

By CAPT. E. MOORE, M.C., R.E. (S.R.).

THE problem of forcing a crossing over a fairly wide river which cannot be forded, the opposite bank of which is held by an enemy, is one which throughout the war has considerably intrigued the sapper. The part played by the sapper is naturally one of vital importance to the success of the operation, and I venture to suggest therefore that no efforts should be spared in reaping to the full the experience gained in the past War to devise a really practical and efficient method of effecting this end. With this idea in view I am going to describe as briefly and concisely as possible a method which my company put successfully into practice a few days prior to the Armistice which enabled infantry to cross the river Scheldt.

It is true that at the time referred to the situation developed so rapidly that, unknown to ourselves, the enemy had left the opposite bank and no opposition was encountered.

However, the operation was carried out during the night on the assumption that opposition might be expected; furthermore the difficult part of the job—namely, the bringing up and successfully hiding near the bridging sites the large number of rafts and bridging material—was carried out on bad roads and wet weather and under a considerable amount of shell fire.

I think readers will agree in the particular type of bridging operation I am going to illustrate, that provided everything necessary for the operation is found at site, the actual launching of the bridge has very nearly as much prospect of success as infantry having to ford a river under fire.

The river to be crossed was about 100 ft. wide and had a current flowing at from five to six miles an hour. Five places in all were selected and allotted to my Field Company to tackle.

The method consisted of booming out and connecting up a series of rafts 9 ft. by 8 ft. made to the dimensions shown on accompanying *Plan* A with a 2 ft. duck-board walk running through the centre.

Plan B shows how each raft is interlocked and fastened together with two short lengths of spun yarn at E and F to keep them from floating apart. The stability of this bridge depends entirely on this interlocking device, which is the most important part of its design. It is advisable therefore—as well as skew nailing

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together with 6" nails the component parts of each raft—to also lash with wire the ends G. H. K. L. as a big strain comes on these ends, tending to draw any nailing done here.

The dimensions and shape of this raft were evolved by actual experiments with rafts of different combinations of timbers, and this particular design and shape were found to give the most effective buoyancy for weight of timber and convenience in handling.

The rafts and duckboards were built separately a convenient distance behind the line and carried up in pontoon and G.S. wagons under cover of darkness, and dumped in farms and against odd buildings which happened to be situated not more than about 100 yards behind the river bank. In no case was there a very big carry from the dumping ground to the sites chosen for crossing.

Pontoon wagons were naturally found more suitable than G.S. wagons for carrying up the ready made rafts. The duckboards were carried up separately, as they packed better this way, and it was found that there was a tendency for them to be broken and torn away from the rafts in transit if brought up in one piece.

For a river up to 100 ft. wide, with about five miles an hour current flowing, one u.s. cable made fast on shore and connected to the centre raft is sufficient to keep this bridge from bulging, and if time and situation permit this can be increased and a hand rail added.

The method of constructing is by booming out one raft after another from ways made fast on the shore, when the far side is reached the end rafts are lifted up on to dry land and picketed down.

Before Zero hour the rafts would be brought up by a separate carrying party from the dump to the actual bridging site just behind the river bank if it has one and each raft laid out on the ground.

At Zero special picked bridging party of one officer, three N.C.O.s and 16 men form bridge according to the simple drill or organization which I have written out and which is self explanatory.

It will be noted that this drill is of the simplest character and involves no effort of memory so that it is possible to replace any casualties by any technical or non-technical man who happens to be available at the time.

The only requirements of this bridge in the way of ropes are two head ropes, one on each side of bridge on the first raft, to steer the bridge as it is being boomed out and one u.s. guy made fast to the centre of the bridge and anchored on shore as indicated in *Plan* C.

As in all bridging operations light easily handled boats are a "Godsend." I have included in my accompanying drawings a dimensioned plan of a very easily constructed and serviceable boat.

I do not lay any claims to the invention of this design and have only introduced it in case it may not yet have found its way into any military publication, or have been permanently recorded for future use.

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I have built and used this type of portable boat in night operations and think it a very practical and useful design, and it deserves wide circulation.

DRILL FOR FORMING WOODEN RAFT FOOT BRIDGE.

1. *Assumption.*—Rafts laid out in convenient piles of four on some covered place about 40 yards from water's edge.

2. *Required.*—Three detachments of one N.C.O. and six men and one officer or senior N.C.O. in charge of whole.

3. *To form bridge.*—Nos. 1, 2, 3 and 4 of "A" detachment carry up two launching ways and two short square pickets and a maul, and picket down the two launching ways, and stand by to take over the u.s. and d.s. head ropes of bridge. Nos. 5 and 6 of "A" detachment remain on either side of launching way during booming out and assist in locking rafts and lash each raft to the other with spun yarn. The N.C.O. of this detachment is responsible for the correct alignment of the bridge.

The remaining two detachments "B" and "C" bring up rafts in turn, and boom out. As soon as bridge touches opposite shore "B" detachment go across to opposite shore, heave up the head raft, cast off the two head ropes, and make fast the head raft in the shore and the u.s. cable to the centre of the bridge.

"C" detachment do likewise to the last inshore raft and make fast the centre u.s. cable to a shore anchor.

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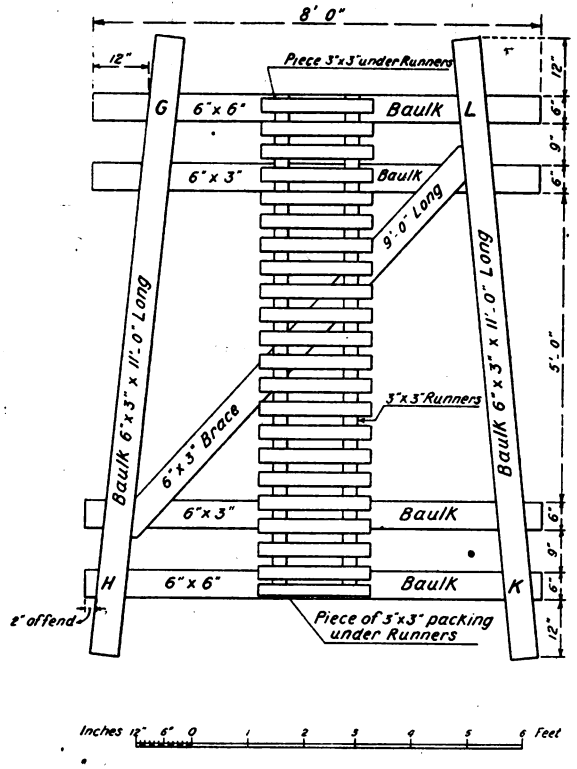
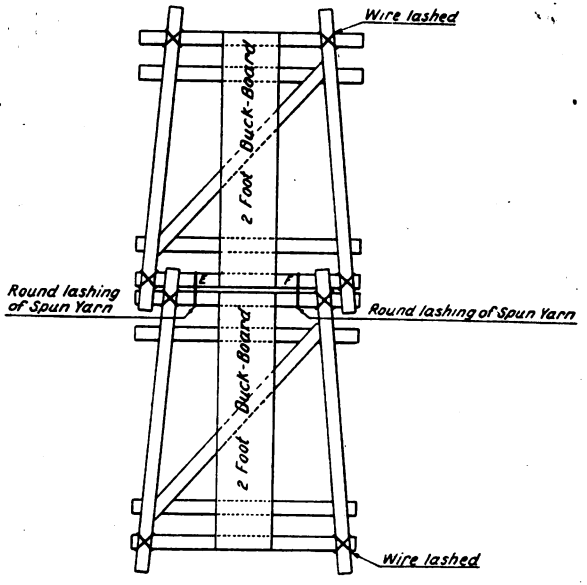
FLOATING BRIDGES FOR INFANTRY

— Plan A showing details of one Raft —



— Plan B showing —
Method of inter-locking the Rafts



E. Moore
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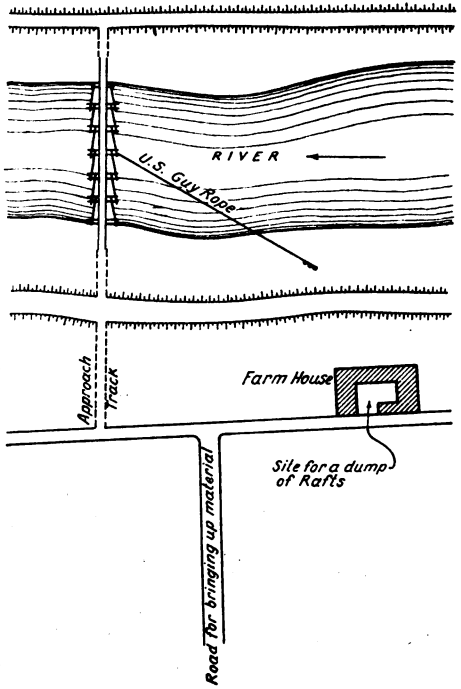
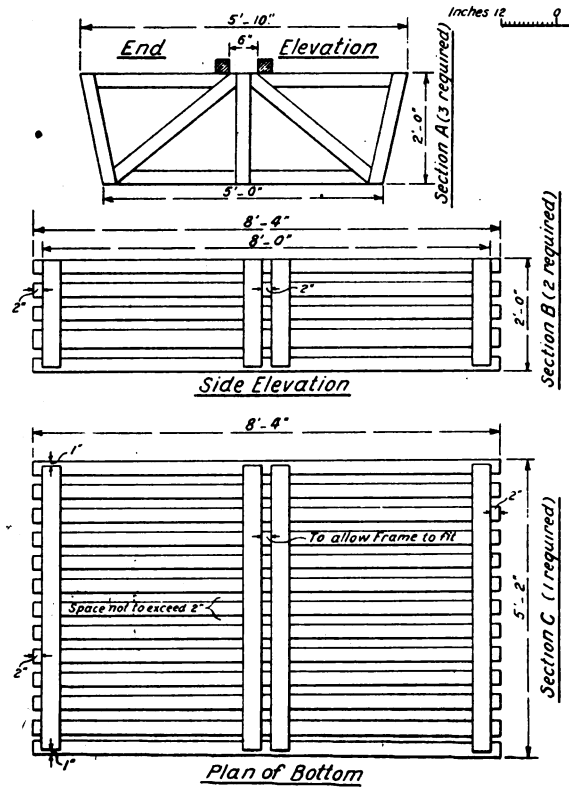
FLOATING BRIDGES FOR INFANTRY

— Plan C showing — a general view of a suitable site



— Improvised Boat for 12 Men —



Stores required to make Boat

6 Timber Sections.
1 Bivie Sheet 13'-0" x 10'-0".
10 1" Lashings or Spun Yarn each 3 fathms in length.

Stores to accompany each Boat

1 Maul & 2. 6 ft. Pickets.
1 Breast Line for painter
3 R.E. Shovels as oars.
1 Cable (2") depending on width of stream.
1 Baler
2 Spare Breast Lines

To make Boat:

Lash the 6 sections together with spun yarn.

Place the skeleton on Bivie Sheet layed out on ground, fold sheet over sides and ends of boat and secure with lashings where necessary.

E. Morris 15. 2. 21

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SCIENTIFIC MANAGEMENT AND MOTION STUDY.

A Lecture delivered at the S.M.E., Chatham, on 12th January, 1921, by F. JAMES BUTTERWORTH, ESQ.

I HAVE been asked to give you an address on the subject of Scientific Management, and Motion Study. This whole question of the reorganization of industry is so vast, and can be approached from so many different sides, that I can only hope to give you a very general idea of its possibilities in the course of one evening. When you consider that not only the engineers, but the psychologists, the physiologists, the economists, and the sociologists, are all falling over each other in their eagerness to contribute their share of knowledge for the good of the workers, and the betterment of working conditions, I think you will agree with me that to-night I shall only be able to show you the " high lights."

The late war was the most incalculable disaster to the human race, but in spite of this it has, in certain directions, done much good. To mention one aspect only, it has been the means of arousing a national conscience in all classes of the community. People have come to realize that the very least that can be done in return for the sacrifices that have been made is that no effort of mind and heart and will should be spared in the task of making this country and the empire generally a fit one for everybody to live in.

There are different ways of trying to do this. To each country its own method. Personally I believe that we in Great Britain will be able to evolve a method which shall be a model to the whole world. But we shall only be able to do this if we avail ourselves of what the scientists and engineers in this and other countries have discovered, practised, and are continually improving upon by patient and laborious research.

For the last three generations the working people of this country have not had a square deal. On the other hand, the employers will make the same complaint. The reason for these two statements is not far to seek. In the past, under the old or traditional forms of management, the interests of the employer and employee lay in opposite directions. Hence, mutual mistrust, ever present suspicion, rate cutting by the management, shirking by the workers, continual friction, strikes, lock-outs, each side trying to get the better of the other, the inevitable result being a low standard of living for the

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workers, and a high cost of production for the management. This last factor reacts in its turn on the workers, causing as it does an ever increasing cost of living with which rising wages are not able to keep pace. Thus traditional management with its non-economic foundations, makes for a vicious circle. Nobody benefits by it, markets are lost, and the workers get the worst of it every time. *The interests of masters and workers are identical.* When this is realized, and not until then, we shall get that co-operation, that united, instead of divided, effort, which at one stroke will do away with half the moral and material waste from which this country is suffering to-day.

It is this problem of how to combine short hours and high wages, in other words, a high standard of living for the workers, with low costs of production to the management, and a consequent cheapening of the product to the public, that the new or scientific or measured functional management has set itself to solve.

The late Dr. F. W. Taylor, of Philadelphia, who died in 1915, was the first to call the attention of the present generation to his discovery of Scientific Management, although his claim to be the discoverer is now contested, it having been found that Marcus Aurelius, born A.D. 121, in his *Meditations*, book 4, page 33, called attention to unnecessary actions—physical, and in speech and thought—and advised their abandonment. Francis Bacon (1561) in his 25th essay, on "Dispatch," travelled upon the same lines, and in later, but far distant days, the French Physicist, Coulomb (1736), Adam Smith (1723), in his *Wealth of Nations*, and Charles Babbage (1791), the inventor of the calculating machine, all had wise things to say on the subject.

Many of the ideas of Scientific Management can thus be traced back to these mighty philosophers of past ages, but the science of management, as we now know it, was discovered and its principles made practicable when Taylor invented time study and used these units of measurement, *prior to performance*, to determine the amount of work a worker could do, and the amount of rest necessary to overcome fatigue. Not until then did management become a science.

Management may be divided into three types:—(1) Traditional; (2) Transitory; and (3) Scientific, or measured. In the first, the managing is usually done by a capable "allround" man—thus authority is clear, fixed, and single. The second is self-descriptive, and the third is a real science.

As there are probably some among my audience who have not had the opportunity of studying the text books on the subject—they are mostly of American authorship—a list of the leading works on the subject is to be found at the end of this lecture. I will give you a brief outline of what is meant by Scientific Management, and then speak of one of its sub-divisions, namely, Motion Study.

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I have been interested in these questions for years and have kept in close touch throughout that period with some of the leaders of the movement, through my friendship with Major Frank B. Gilbreth, the author of *Motion Study*, and jointly with his wife, of *Fatigue Study, Applied Motion Study, Motion Study for the Handicapped*, and other works. Assisted by his gifted wife, the author of *The Psychology of Management*, he has made the psychology and welfare of the worker a special study.

There is confusion in many minds to-day as to the meaning of Scientific Management, but when I state that it is management based upon actual and accurate measurement, its scope and object will be made clear to such an audience as I am now addressing.

Its skilful application is an art that must be acquired, but its fundamental principles have the exactness of scientific laws, the study of which is open to all. There is nothing secret or hidden about it, for it is a science that is the result of accurately recorded, exact investigations, the results of which have been formulated, and further findings are being added to it every day. The scope of this science is unlimited, for it applies to every field of activity, both mental and physical, and its laws are universal. Its fundamental aim is the elimination of waste of every kind with the attainment of the desired results by the least necessary amount of time and of effort; it may and often does result in expansion, but its primary aim is conservation and saving, by making adequate use of every particle of any type of energy expended.

The old saying, "The proper study of mankind is man," has assumed new meanings since the votaries of this new science have divulged their findings to the world, for they have taught us that success in handling both the human and material elements depends upon the exact knowledge of the element itself and the acquired experience as to how either or both can best be handled. Through motion, fatigue and time study the capabilities of the workers have been determined. The exactions of the work and the fatigue of the workers which result, together with the amount and nature of the rest to overcome such fatigue, are known, and their practical application of the findings to the industries have been fraught with the happiest results to employers and employed alike, for they have increased output, decreased working costs, and added to the wages earned by the workers. Agriculturists have taught us that it is possible to get great annual outputs and conserve producing force unimpaired by judicious use of suitable fertilizers. The knowledge of how to keep the soil at its fullest producing capacity, making provision for depleted energy, is largely standardized and widely practised. Industrialists should realize these facts and apply them to their workers. The sooner these workers can be treated to overcome fatigue and regain their normal working capacity in the

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shortest possible time, the quicker will the toiling masses and their employers benefit. Suitable provision for such recovery in the industries, before the days of scientific management, was unknown.

I therefore appeal to all to increase their knowledge of industrial conditions and necessities so as to increase production, which alone can prevent disaster and ruin to the nation.

The management of all works, great or small, must realize it is absolutely necessary that a "thinking and planning" department be established in the very beginning. If any person's ambition leads him to wish to win races or other athletic contests, he can find out the recorded times of performances of previous champions; and if he desires to lower the record, he knows exactly the time he has to beat, and practises and trains accordingly. The annals of sport are full of such records. Can any of you tell me where such records are available to the industrial worker anxious to improve his craft skill, and earn more money? Which of such records would be most productive of material prosperity and happiness to the nation? The records were not taken in the case of the athlete to "speed-up" or "drive" him, but to co-operate with him in showing what was reasonably attainable.

As "standards" will be referred to later I will explain what the term means.

Mr. M. L. Cooke, of Philadelphia, has said a "standard" under modern scientific management is simply a carefully thought-out method of performing a function or carefully drawn specifications covering an implement or some article of stores or of product. The idea of perfection is not involved in standardization. The standard method of doing anything is simply the best method that can be devised at the time that the standard is drawn; further progressiveness is desired and is adopted whenever and wherever found, after being carefully scrutinized. Standardization practised in this way is a constant invitation to experimentation and improvement.

This experimentation and improvement is done by time and motion study (*i.e.*, the study of the body's or machine movements) before the standards are made; thus the resulting standard is in so far protected that only the invention of a new device will make the change in such standard necessary. Standards have been advanced by a mere timing of the operation by mental counting. Good work has been done by stop-watches, but where exactness, precision and a permanent record are necessary, micro-motion studies, elaborated by Major Frank Gilbreth, of which I will show examples presently, give the best results.

In practice it has also been found that such studies bring out many hitherto unsuspected defects in surrounding conditions, most of which are beyond the power of the worker to change, but which enable the management to eliminate many drawbacks, and thus increase

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efficiency and output. In one case I have heard of, a drilling machine was fitted with a claw-operated heavy jig; the machine had high-speed drills and was not suitably speeded, and the 15-lb. parts to be dealt with were on the floor, entailing lifting up and putting down when finished. By a suitable re-arrangement of the machine and letting gravity deal with the parts, an increase of 120 per cent. was gained with less effort to the operator.

In another case close observation and timing showed that a machine could be slightly accelerated, thus gaining 1½ seconds in the cycle. This seemingly small improvement, when applied to a number of similar machines in use, amounted to a total of over 20,000 hours in the year—a truly remarkable and substantial economy. The savings indicated in the foregoing instances do not mean the reduction of employment, for alternatively two things might happen. Firstly, another country might discover the cheaper and faster method, thus causing us to lose the market; secondly, if all nations keep the faster method from being adopted costs will remain high and the article will remain a luxury.

We have illustrations of this in all trades. For instance, take boots. Until the past few decades most workers had to use clogs; their grandfathers were probably bare-footed, and it was only when elaborate boot-making machinery was invented that good boots were reduced to a price within the reach of all classes. Increased production here meant health and comfort to millions, and greatly augmented good and steady employment to scores of thousands.

The first step in introducing Scientific Management is the adoption of "*standards*" throughout a works. By this is meant not only standard machinery and tools, but standard methods of performance, standard mnemonic symbols, standard phrasing of instruction cards —of course this means that an investigation and planning department has been established—but even standard clothing, which should be provided by the management, together with a proper dressing room. This would mean clean and tidy workers in the trains, trams and busses.

To a careful observer there is nothing more disheartening than a study of many workers' clothes, especially those of women workers. One has only to consider how this question has been thought out where sport is concerned, to see the enormous strides which could be made for increasing the efficiency of the worker, by having well-thought out, substantial garments, suitably designed to fit the particular occupation of the worker.

For tennis, football, running, boxing, golf, etc., the garments worn do not in themselves increase fatigue. Why should not the workers' clothes receive the same attention as those of the athlete?

Functionalization or the sub-division of labour, is the aspect of Scientific Management which has perhaps come in for the most

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criticism. This is what Prof. Jules Amar, the great French physiologist, says on the subject—"There is in the division of labour a scientific solution of the problem of occupying everyone on the work that best suits him. And there are so many developments possible to human activity that every worker ought to find his niche without delay." Functionalization endeavours to do this; its aim is to take round pegs out of square holes, and *vice versa*, and fit them where they will have a chance of developing their individuality, and to put all workers at the work for which they are physically and mentally fitted.

Under this system the planning is separated from the performing; the hitherto overloaded function of foreman is split up under various heads, and all workers know exactly what is expected of them, and how they are to do it. This method not only increases the productivity of the worker, but diminishes executive fatigue, which is one of the main causes of slipshod management. I will enumerate the eight main functionalists, four in the planning and four in the performing departments—Order of work and route clerk, instruction card clerk, time and cost clerk, disciplinarian, gang foreman, speed foreman (to speed the machines *not* the men), repair foreman, inspector. I have not time to go into this fully now, but I would like to say a word about the disciplinarian. He is not so alarming as he sounds. He is a man chosen for his tact and judgment who deals with all questions relating to discipline, fines, discharges, etc. He is really a peacemaker. A complete record is kept of every man's work, whether good or bad, and this is at the disposal of the disciplinarian. In this way every man is sure of a fair hearing, and he knows that he will not be fined, punished or discharged through the personal spite or dislike of his foreman. In some cases, even the latter, if making an unfounded complaint, is disciplined.

These *records* which I have just mentioned are an important part of the system. They are kept not only of the individual performance and behaviour of every worker, but of the work itself. There are no "book-keeping" records as such, but time and cost records, of the time and efficiency of performance. Just as records are kept whilst the work is going on, so *programmes* are always made before starting fresh work. New programmes are based on past records, and so, as more and more records become standard, the drafting of programmes becomes constantly an easier and cheaper process.

Analysis and *Synthesis* appear late in the science, and are of course based not only on measurement which I have not yet touched upon, but upon previous records. The nature of the work must determine the amount of analysis practicable, and in determining whether the work shall be scientifically analysed it is necessary to consider whether it is of sufficient importance to warrant the expenditure of a large amount of time and money upon it, prior to the undertaking. The

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process of division continues as long as it can show itself to be a method of cost reducing. "Work may be divided into processes; each process into sub-divisions; each sub-division into cycles; each cycle into elements; each element into time units; and each unit into motions. The work of the synthesist is to study the individual results of the analyst's work and their inter-relation, and to determine which of these should be combined and in what manner, for the most economic result. He has to conserve all that is valuable in old methods and combine it with the new.

A complete lecture could be delivered on *teaching* under Scientific Management, but I have only time to touch upon it now. Under the old systems, there was practically no definite scheme of teaching by the management, and the apprentice learned in a haphazard way, and often from poor methods; the old belief being that the worker must go through all possible experiences in order to acquire "judgment" as to best methods. In other words that he should learn by his own mistakes, an expensive process for the management. Under the new method, the apprentice is taught by a definite system, the right way from the very beginning. As he can start in where others left off, he can learn much quicker and go much further.

Incentives, under scientific management, can be defined as inducements to the worker to increase his efficiency, and a stimulant to prevent indifference to the work. Under "stimulants" we can place pleasant and sanitary working conditions, good heating, cooling, lighting and ventilating, and the recognition of individuality under the record system. Under inducements, the knowledge that if a man works his best he will be benefiting himself, but not doing his fellow-worker an injustice. There are far more chances of promotion than under the old system, for the simple reason that there are far more executive posts to be filled. Finally, there is the important question of pay, with fewer working hours; for every man may earn abnormally high wages provided that he works faithfully according to instructions and completes a task that has been fairly determined by scientific—and in the future I hope—psychological and physiological data.

Might I ask whether improvements could not be effected in shovelling, of which there must be a great deal done in the army. The late Dr. Taylor when manager of the Bethlehem Steel Works was struck by the fact that there was only one type of shovel in use for all purposes. He found that the maximum weight that a man could lift, without undue fatigue, was 21.5 lb., and he had the shovel blades altered accordingly. He had smaller blades made for coal or ore than for breeze. Finally, some thirteen different types of shovel were used in the works. The effect of the change was that in a given time the weight lifted per man per day went from 16 to 56 tons.

Tall men should be put to work on excavating, or where material

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has to be lifted to a height ; and the short men to turn over material on the ground, such as mixing concrete, mortar, etc. The latter not having to stoop so far as the tall men, will get less fatigued, whilst the latter would have the advantage in trench digging, not having to throw their spadeful so far.

In some cases the individual cannot work more than 42 per cent. of his time ; 58 per cent. of rest being necessary. Consequently, at the steel works above mentioned, rest periods were regularly given. In heavy labour if they made a man rest 58 minutes in 100 minutes he would do three or four times the work in a day than if he was employed continuously. Dr. Taylor found that when a man lifted continuously more than 92 lb. at a time he was over-fatigued, and that weight was therefore made the limit, the pigs of iron being cast at that maximum. When a man had carried five pigs he was made to sit down and rest for a rather longer time than he had been carrying. The man at piece work earned 70 per cent. more wages per day, and whereas he formerly carried 12½ tons, he was able to handle 47½ tons, though he worked less than half time. Very similar experiments in trench digging in France during the war led to exactly the same results. By giving the men periodical rests, over three times the amount of work was done in a day, the rest periods being strictly enforced. Production in many industries is seriously reduced, because the men work too long without rest, and so are over-fatigued. As an instance in one works men turned out 16 articles per hour when working at their own pace. Working 25 minutes and resting five minutes alternately, they made 18. Working 17 and resting three, they produced 22, and finally, working 10 and resting two, they did 25. Short period and short rests give better results than long periods and long rests.

Time study is one of the most important factors in scientific management, its function consisting of ascertaining with accuracy the minimum times of all operations. Those who have never investigated such operations cannot realize the enormous benefits to be derived from such study. Under the old methods the foremen and shop managers were considered to be the only competent judges in such matters. Their opinions were sought, as they were supposed to have experience, and perhaps data from previous operations. Usually such notes, if found, were discovered to be too rough and lacking in essential particulars. In spite of this, they were left to fix times and prices, often with disastrous consequences. As a case in point I may mention the following incident. During the war a French works had to repair a torpedoed ship. The head foreman spent about six hours in looking over her, and estimated it would take 12,000 hours to repair the damage and perhaps mean a 30 per cent. time bonus to the men over their ordinary pay. The work was begun, but here the new timing department took a hand in the game.

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They checked up the work by the new methods and found it should only take 4,600 hours, and they fixed this as the basis of payment. It was done in even less time, and the men earned a 45 per cent. bonus.

It has been asserted that "what Darwin was to Science, Taylor was to Industry." To sum up, he puts forward in his book *The Principles of Scientific Management* the following five principles:—

1. Science not rule of thumb.
2. Harmony not discord.
3. Co-operation not individualism.
4. Maximum output in place of restricted output.
5. The development of each man to his greatest efficiency and prosperity.

The foregoing are all sound and good, and his system is practically perfect.

Before starting new methods and going to the trouble and expense of subjecting them to an intensive study, it is advisable, where possible, to begin with a survey of the old existing conditions. Gilbreth says that such survey may consist of a written description, supplemented by all available data—such as drawings, sketches, photographs, etc.—for recording what exists, what is taking place, and the times taken over the operations. It will serve as an important basis for the necessary future comparisons, and show what improvements in time or method are to be aimed at. The difficulty in preparing such a survey is to set down correctly what does exist. There is great temptation, especially if it is being done by an interested party, to set down instead what ought to exist, what is hoped will exist, what is planned should exist, rather than what is actually there. Try it for yourselves.

When you return to your work set down, or get a competent substitute to do so, what actually occurs in your place during one typical half hour. Add to this drawings showing the "set-up" or "lay-out" of your work, and where each piece of working equipment is placed, etc. Where plans exist, use them as a basis, drawing in the small objects. You will find this most interesting and stimulating as an attempt to make a survey of your own working conditions and practice, and you can then review it intensively, and then begin to introduce motion study.

Motion study is the science of eliminating wastefulness resulting from unnecessary ill-directed and inefficient motions. There are no ravages going on in nature to-day that equal the hourly losses the whole world is suffering from as the result of the wastage of human energy. Wasted motions cause wasted effort and time, and one of the results is unnecessary fatigue, another prime cause of high costs. Time is our greatest asset, and to waste it is to squander our inheritance. To waste time and to suffer unnecessary fatigue simultaneously can be excused only by ignorance. When we come to

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necessary fatigue we cannot proceed far without recourse to careful measured investigation. These always show that less fatigue is necessary to do the work that has been anticipated.

In the final analysis, whether the fatigue proves to be necessary or not, it must be eliminated or cured, that is, recovery periods must be instituted. There are two methods of fatigue elimination—one the short method of removing the cause, the other by supplying the remedies.

What is not generally recognized is the following physiological fact pointed out by Professor Amar: "The fatigue of the nervous system is in proportion to the number of motor impulses which it is obliged to furnish to the muscular system in order to cause the latter to function, and here we see why in certain kinds of work which do not require strength there is considerable nervous exhaustion, while fatigue soon makes it appearance." Dr. A. F. Stanley Kent also believes that "the seat of fatigue is rather on the nervous than on the muscular side." You must realize from the beginning that fatigue study is a necessary complement to motion study, and that the fatigue which is the outcome of the motion must never be forgotten.

For instance, a long motion may occupy no more time than a short motion, but the fatigue will be greater with the amount of the distance traversed, all things remaining the same. Motion economy also involves a consideration of delays, the reasons why they occur, and a reconstruction of the method to such an extent that avoidable delays are eliminated, and that unavoidable delays are made rest periods or otherwise utilized.

The great and important result of motion study will be the change in your mental attitude. Nobody can really appreciate the benefit of motion economy who has not made motion study in his own work-place upon his own work, for you will see your own work-place yourself, and all that you do, in a new light. All activity outside and away from work will have more significance, and, perhaps the most important of all, you will see, more and more each day, the underlying elements of likeness in all types of activity. Just as there are physical elements, so there are elements of skill. You will come to distinguish between skill and mediocre activity or bungling activity, and to note that an expert in any line bears certain resemblances to experts in other lines.

Motions of experts in all activities are alike; all are smooth, all are graceful, all show decision without hesitation, and all produce that satisfaction in the spectator that they produce in the creator of the motion.

I will now show you a series of pictures, a few of many thousands, taken by Major Frank B. Gilbreth. In the evolution of scientific management, motion study as elaborated by him, and his application of psychological laws to the workers, have become important items.

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In all motion study you must first have your units to measure, then your methods of measuring, and finally, devices to measure quickly and cheaply. Measurement is indeed the foundation, the base line of scientific management.

Many may consider the apparatus he uses expensive and elaborate, but I wish to emphasize particularly the fact that such equipment is not necessary for preliminary study. In fact, to realize thoroughly the need of more accurate measurement, it is first necessary to devote much thought along the lines of motion economy, and to work without any equipment. To make accurate studies of operations being performed wrongly, is a waste of time, energy, and money.

Many photographs were then shewn, of which we reproduce seven* with descriptions.

1. A micromotion photograph enables the worker, with all surrounding conditions, to be permanently recorded. The elapsed time of an operation is visually recorded in a series of pictures, by means of the clock, the single hand of which moving through 100 divisions in three seconds, measures 1-2000th of a minute. The extent of the motions made are measured against the screen in the background, which is cross-sectioned into 4-inch squares. Major Gilbreth is standing behind the clock.

2. By means of an electric lamp attached to the hand, or other working member of the body, or the parts of a machine, the path of the motions executed can be traced in the cyclegraph photograph.

3. Various types of cyclegraph time spots, usually numbering 20 to the second. By counting the spots in the photograph the elapsed time of a motion is ascertained. When spots of different types appear in a picture, it shows the separate paths of the motions of various working members.

4. Learning the paths of least waste. Models in wire of the motions of the left hand of a man using a drillpress, a machine he had not touched for 25 years. Note the gradual progress to the practically perfect motion.

5. Cyclegraph of the perfect motion, after considerable practice, on the same machine by the foreman. The "kink" shows where the piece dealt with was "positioned" during the time of transport loaded. This study and the rearrangement of the feed-boxes, etc., cut down the operating time by one-half.

6. A Gilbreth assembly packet. Formerly all parts were kept in boxes or bins on the floor, benches, etc., entailing turning and stooping. Arranged in proper sequence on these wall packets, with table at the right height, tools in their standard locations, the workers were enabled to assemble 66 machines per day against a former output of 18, in less time and much less fatigue.

* The photographs are from Major Gilbreth's collection, and we are indebted to him for permission to make use of the same.

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7. Picture of an American Amateur Champion Golfer. Lights attached to his head and hand, and to the head of the club. Note the movement of his head, it was found that all players *do* move the head. The beautiful regularity of the stroke is clearly seen. Its extent is measured on the screen, and the time taken over it can be ascertained by counting the number of spots.

If I have convinced at least some of you that scientific management is not, as some from honest ignorance think, a mere device to exploit the workers, but a real living force capable, when properly installed and handled, of conferring untold benefits on all concerned, I shall feel rewarded.

I cannot finish better than by quoting Professor Amar's dictum on Scientific Management: "Selection and order are in truth the characteristics of the new method, which will presently work an economic revolution to which no other can be compared. It is not purely mechanical, it does not turn a man into a soulless body, a blind and tireless force, it embraces all the data of physiology and psychology, of which it alone is able to display the parallelism and the unfailing harmony. It would seem to have taken for its guide this saying of Montaigne's: 'It is not a body, it is not a soul that we are forming, it is a man, we must not make two of him.'"

BOOKS ON SCIENTIFIC MANAGEMENT.

The Principles of Scientific Management and *Shop Management.* Both by late F. W. Taylor. (Harpers).—*Motion Study.* By F. B. Gilbreth. (Constable).—*Applied Motion Study.* (Routledge).—*Primer of Scientific Management.* (Constable). and *Fatigue Study* (Routledge). By F. B. Gilbreth and L. M. Gilbreth.—*The Psychology of Management.* By (Mrs.) L. M. Gilbreth, Ph.D. (Pitman).—*Work, Wages and Profits* and *Organizing for Work.* By H. L. Gantt. (Bird).

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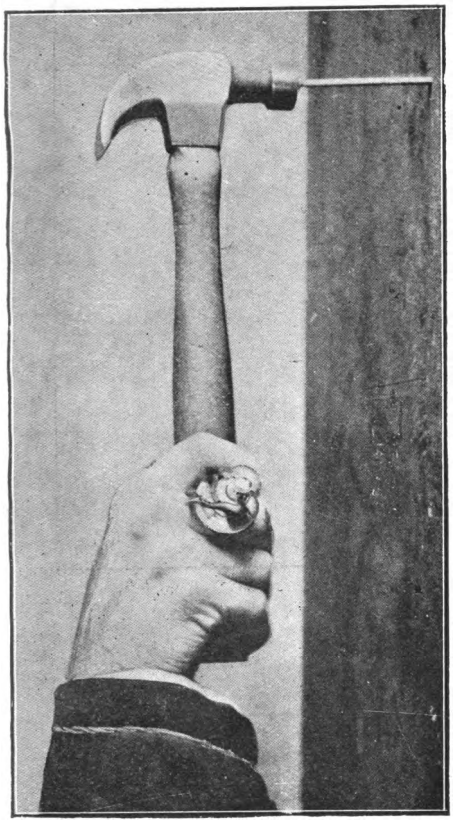
SCIENTIFIC MANAGEMENT AND MOTION STUDY.



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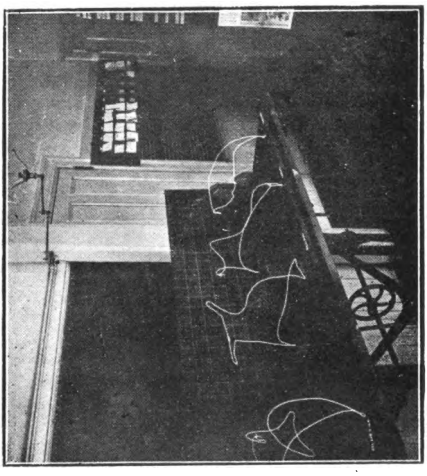

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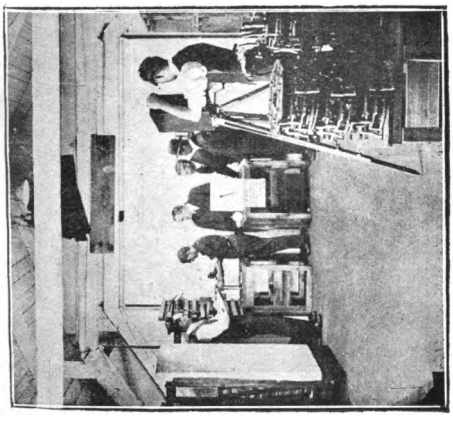

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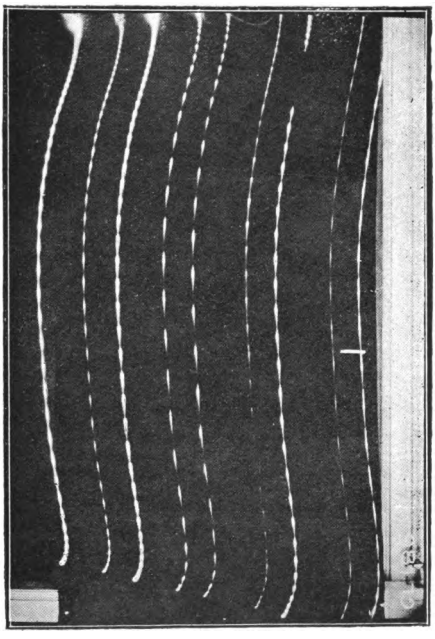

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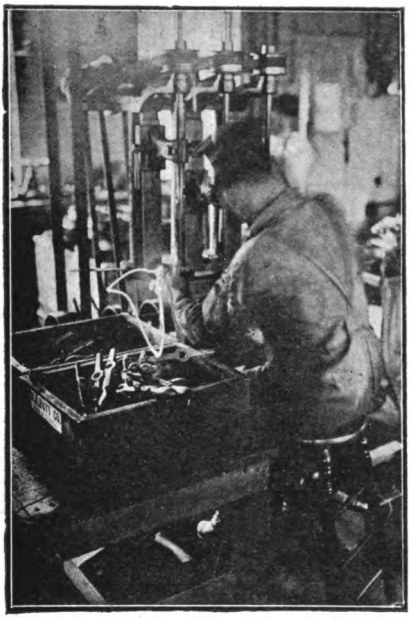

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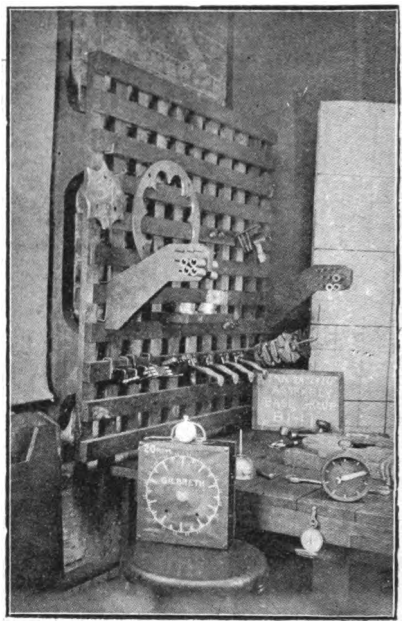

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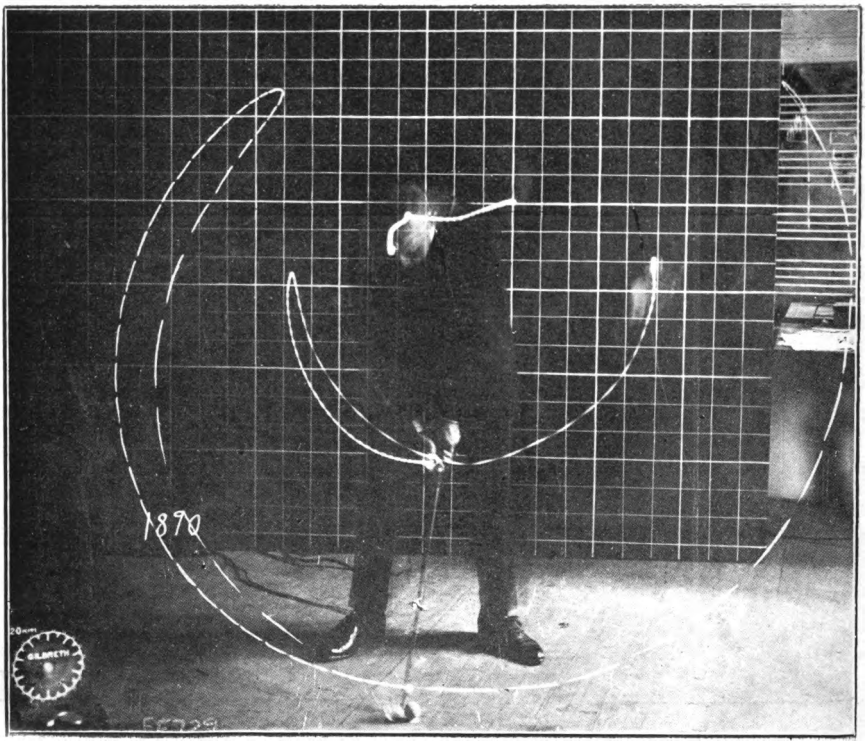

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VERDUN AND METZ.

A Comparative Study of the Fortifications, taken from an Article in the "Revue du Génie Militaire" of January and February, 1921, by General Benoit, Chief Engineer of the Military Command of Metz.

By CAPT. C. LA T. TURNER JONES, D.S.O., M.C., R.E.

(*Concluded*).

VI. THE CONDITION AND COST OF THE FORTIFICATION OF VERDUN AND METZ AT THE COMMENCEMENT OF THE WAR.

Verdun.—At the commencement of the War, Verdun had two rings of detached forts in addition to its citadel and its old enceinte. The inner ring varied between 2½ and 6½ km. from the town and, with the exception of Tavannes and Souville, was without armour or concrete. These two had some concrete shelters and Souville had a turret for a 155-mm. gun; the outer ring, 5 to 8 km. from the town, had concrete works and a certain number of guns behind armour or concrete.

The fortress had in all:—

6 disappearing turrets for 155-mm. guns for long-range firing;

14 disappearing turrets for 75-mm. guns (28 guns) for firing on the foreground and for flanking fire;

23 Bourges casemates (46 75-mm. guns) for flanking the gaps;

in addition, 203 revolver guns (guns with 12 chambers), eight 90-mm. guns for enfilading the ditches, 86 smooth bore mortars of little value and 210 machine guns available for the forts or the gaps.

The guns for the artillery battle and for long-range firing were distributed in about 130 batteries and consisted of 670 guns, many of obsolete type—12 batteries had concrete shelters for the gun teams and for the ammunition, the remainder had only masonry ones. The artillery munitions were stored in eight main magazines dug into solid rock, whence they were distributed to intermediate underground dumps and battery magazines by a well-organized light railway of 60-cm. gauge. 611,000 rounds, or an average of 800 per gun, were stored in the fortress. Observation of fire could be carried out from 45 armoured O.Ps. in the forts and 23 concrete O.Ps. in the Bourges casemates. 16 company, 18 half company, concrete dug-outs, as well as some deep dug-outs, had been made in the gaps between the forts.

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The perimeter of the outer ring of the forts is about 45 km.; the forts are 1½ to 2½ km. apart, except Charny and Froideterre, on the banks of the Meuse and on the down-stream side of the fortress, which are 3½ km. apart.

The forts of the Heights of the Meuse had not been strengthened since they were built, except the fort Liouville which had a few concrete shelters and some armour, viz., one turret of cast-iron for a 155-mm. gun, one for 75-mm. guns, and one for machine guns.

The forts of Verdun, armour included, cost from 1874 to 1914 about 55 millions of francs, about 70 millions if the engineer services carried out during the same period are included, and 78 millions, including the guns and ammunition. This is less than the cost of a single battle cruiser.

If the cost of the guns and ammunition placed in the gaps be included, although in actual fact these were placed at the disposal of the field army, the cost is brought up to 127 millions. Adding the value of the enceinte and the citadel, the total cost is brought up to 165 or 170 millions.

The engineer work on the forts of the Heights of the Meuse cost an additional 17 millions, bringing the total cost to about that of two battle cruisers.

Metz.—Of its ancient citadel, Metz has only retained the old forts of Moselle and Bellecroix; the remainder was demolished in 1902 and replaced on the south by a defended iron fence. It also possessed two rings of detached forts, one 3 to 4 km. from the town and the other 5 to 11·5 km.

The inner ring consists of nine forts of which two, Saint-Quentin and Plappeville, are joined by a continuous obstacle protected by infantry works. This ring contains 6 guns in revolving turrets in the forts, and 22 guns, also in revolving turrets, outside the forts, distributed in six armoured batteries.

Between the forts are numerous batteries in earth-works most of which are near concrete shelters for the gun crews and for the ammunition. These concrete shelters, 80 in number, are scattered over the whole area and consist of 25 for ammunition, 25 for gun crews and 30 for infantry.

The outer ring contains concrete works supplied with 70 guns in revolving turrets (44 of 10 cm. and 26 of 15 cm.) and many batteries outside the works provided with concrete shelters for personnel and stores. There are no isolated armoured batteries, since all the armoured guns have been placed either in the *feste* or can be considered as forming part of the *feste*. This ring has in front of it a strong though unfinished line on the French frontier side. The works in the gaps are also unfinished. The enfilading of the gaps by artillery fire is arranged for only by 10 77-mm. guns in five casemates. The ring itself is also unfinished for the *feste* only exist on a semi-circle

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with its diameter running N.E. to S.W. joining the *feste* Lothringen and Von der Goltz. North of this line there are only two forts, Lauvallière and Mey, the latter being 8 km. distant from Lothringen. The Germans proposed to construct a work on the high ground south of Malroy to fill this gap, but nothing further was done, and they merely threw two pile bridges across the river, one at Thury and the other at Olgy.

At the time of mobilization the fortress of Metz had in all 98 pieces of armament in turrets, of which 60 were on the left bank of the Moselle (22 of 10 cm., 34 of 15 cm. and 4 howitzers of 21 cm.). By their long range of about 10·8 km. the 10-cm. turret guns of the outer ring were able to cover with their fire all the country towards the frontier up to the road and railway, running from Chambley to Conflans; the 15-cm. howitzers, though having only a moderate range (7·2 km.), were able to search the valleys in front of the ring of forts.

The 60-cm. gauge railway did not supply all the works, more particularly certain outlying ones, including the batteries of the line Sainte-Barbe—Sorbey.

The *feste* Wagner and the magazines and batteries of Hospital Wood were supplied by the normal gauge line.

The perimeter of the outer ring is 54 km. or 1-5th more than that of Verdun, and the forts are at distances apart varying from 1 to 4 km. with the exception of the *feste* Lothringen and Mey on opposite banks of the Moselle, and the *feste* Haeseler and Wagner on opposite banks of the Seille, in both of which cases the distances are 8 km.

It would have been almost impossible to determine the cost of Metz as the Germans removed every document dealing with the matter, but documents giving the cost of all the works at Thionville were found there. Germany spent about 50 millions of francs on Thionville, comprising three *feste* with 16 10-cm. guns; this sum being made up roughly as follows:—

6 million marks for Illange, 7½ million marks for Koenigsmacker, 13 million marks for Guentrange (including 2 millions for repairs due to settlement), before the War; 900,000 at Illange, 6 millions at Koenigsmacker, 4½ millions at Guentrange, during the War. The balance is made up in expenses due to the fortification of the enceinte and in the cost of the artillery depôts.

From the above figures and comparing the cost to France of similar works it has been possible to arrive at an estimate of the cost of the works at Metz. This estimate is for example:—

Leipzig, 7 million francs; Kaiserin, 18 million francs (including much underground communication work); Von der Goltz, 19½ million francs (probably would require 5½ millions to complete).

The cost for the double ring of forts including the permanent fortifications on the left bank (Horimont, the Quarries of Amanvillers and

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the position of Bois-la-Dame) appears to be 210 million francs. If the cost of the armoured batteries outside the forts, the various shelters, the strategic roads and the 60-cm. railway be included, the total reaches 250 million francs.

VII. WORKS CARRIED OUT DURING THE WAR.

At Metz, at Thionville and also at Verdun, the completion of works begun and the strengthening of existing works were carried out up to 1916. From the outbreak of war, gaps were defended by trenches and isolated works.

At Metz these works were of more permanent design than at Verdun, concreting being done to the shelters and to the machine gun emplacements, many of which were intended solely for enfilading the gaps.

Dykes were made on the Seille for causing defensive floods and at the same time the gap between the works of Horimont and Mey was closed by the digging of works along the general line Semécourt—Rugy—Chailly—Antilly—Failly. The enfilading of the gaps between the works was carefully studied and was carried out by means of machine gun fire from concrete shelters. An almost continuous line was made on the left bank of the Moselle at Thionville running *viâ* Guentrange and resting on the river, level with Koenigsmacker and Illange. This line had small concrete shelters and a double thickness of wire obstacle 8 m. wide in front of it. There was left only a curtain of less than 14 km. between Metz and Thionville, formed by the Moselle, which could be crossed only by one bridge at Blettange defended by several field works on both banks.

At Verdun, centres of resistance were taken up on advanced positions between the plateau of Sivry la Perche to Côte du Poivre; a certain number of deep dug-outs were made along the line of forts, notably south of the forts of Douaumont and Vaux and at the fort of Belrupt.

Later on, when the fortress was attacked, shelters for the forts and works were extensively increased by the construction of numerous underground galleries, ventilated and lit by electricity and opening into casemates or M.G. emplacements placed outside the forts for the defence of the approaches to them.

At Metz, when the battle became stabilized in the neighbourhood of the fortress, the Germans began the construction of an advanced position towards the south resting on the Moselle near Arry Hill; but it was chiefly after April, 1916, when the attack on Verdun did not come up to expectations, that they really pressed on with these works. They had at this time between Marieulles and Sorbey on an average depth of 500 m. to 600 m. a large number of shelters having thickness of concrete varying from 0·60 m. to 1·20 m.

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These shelters were built either for 12 men or for searchlights, as O.Ps., or for enfilading guns and machine guns; they were spread over three, four and even five successive lines on military crests or on reverse slopes with more or less completed obstacles in front of them. The connecting trenches were hardly begun.

Between Marieulles and Haute-Grève there are nearly 800 of these shelters, many of which were completed by the spring of 1917. This number would seem to be out of all proportion to the garrison usually allotted to a defensive position, but it has the advantage of denying to the enemy knowledge of what points are being lightly held, and gives the defence shelters and opportunities for flanking fire in a lightly fortified area.

The whole of this advanced position was provided with water by pumps from Cherisey and Coin-sur-Seille.

In addition the installation of electric light was proposed by means of power supplied from Diesel engines in Lothringen, where they had been installed for lighting the Horimont position.

VIII. The Effect of Bombardment on, and the Part Played by, these Fortresses during the War.

The Effect of Bombardment on Verdun.—The fortress of Verdun was attacked on the 21st February, 1916, by a strong army with much artillery, including very powerful guns. The violence of the fire passed all expectation.

For the defence the French Artillery fired 9,795,000 rounds in the first three months of the attack, 23 million rounds in the first seven months, of which 16 million were from 75-mm. guns. This gives a daily average of 100,000 rounds, a number more than doubled on days of attack; for instance, when Douaumont was retaken on the 24th October, 1916, 240,000 rounds were fired.

Vacherauville (8,000 rounds, including 110 of 420 m. and 2,140 of 380, 305 and 280 mm.), Froideterre, Souville, Tavannes and La Laufée 30,000 to 40,000 each), Moulainville (8,500, including 330 of 420 mm. and 770 of 305, 280 and 210 mm.) were the forts most heavily bombarded by the enemy. Thiaumont, Douaumont, and Vaux were bombarded by both sides. The town of Verdun received more than 50,000 shell, including about 380 of 380 mm.

The effect of prolonged bombardment showed that:—

(1). Earth-works were completely flattened out; defended railings, wire obstacles and ordinary masonry were entirely destroyed;

(2). Concrete works survived in proportion to their mass;

(3). Heavy shells, notably the 420 mm. ones, made themselves felt at considerable depths up to 14 metres.

As a result (*a*) underground communications, if at insufficient depth, were frequently rendered impassable but if deep enough were quite safe and the men in them were safe from concussion; (*b*) small

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isolated concrete works, such as those at Thiaumont, were more rapidly destroyed than if they had formed part of a large mass of concrete. It was also found that works with a layer of concrete over a layer of sand had the concrete penetrated if this was less than 2½ m. thick, but not if more than 2½ m. thick. Ferro-concrete was pierced if of less thickness than 1·75 m.

The armour survived in an extraordinary way; in the forts of Vaux, Douaumont, and Thiaumont only a few O.Ps. of little mass and machine gun emplacements were destroyed, these not having been built to resist heavy shell.

Damage done to the gun turrets was generally quickly repairable, and none were long out of action. The only turrets for 75-mm. guns which were destroyed at Verdun (Fort Vaux) were destroyed by charges exploded in their barrels by the French.

To sum up, the active elements and the chief passive elements of the forts defied the heaviest artillery attack. Except for the small work of Thiaumont, all the forts of Verdun remained fit for action at the end of the attack.

The Effect of Bombardment on Metz.—It is impossible to guess with any accuracy what would have been the effect of bombardment on Metz. The inner ring could probably have been destroyed by fire from artillery of heavy calibre, as the protection afforded by 1 m. of concrete or 2 m. at the most over 1 m. of sand is quite insufficient. The underground communications of the outer ring were far from being sufficiently protected and might have been destroyed by lucky shots. The batteries and concrete barracks would have required an accurate and prolonged bombardment to do them much harm. The armour, being of only half the thickness of that used by the French, was probably not nearly strong enough.

The Part played by Metz during the War.—The fortress of Metz and the fortified area of the Moselle were not attacked and its long-range guns were not used except that a few 10-cm. rounds were fired from Kronprinz against the Americans in the direction of Rupt-de-Mad. But if the individual forts took no part in the war the fortified area as a whole completely fulfilled its purpose. It covered the concentration of the German troops in Lorraine, it permitted the quick and easy intervention of these troops in the battle of Morhange in August, 1914; under its cover were assembled the troops for the attack on Troyon on the 8th Sept., 1914, and on Saint-Mihiel on the 24th of September; under the screen of its forts was collected a large proportion of the troops for the attack on Verdun in 1916.

It formed a big depôt for munitions and supplies for the German armies of the Woëvre and Lorraine. The fear of seeing large forces appear from the fortified area must have had some influence on our movements on this part of the frontier in August, 1914.

The Part played by Verdun.—Verdun had to meet very powerful

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attacks, in which its forts played very important parts. The forts were incorporated into the various lines of defence held by the Army and were, thanks to their situations, excellent observation posts, and, thanks to their concrete, excellent shelters for the men. The few turret guns, in spite of their fewness, were most useful at longish ranges. For instance, the turret guns of Vacherauville fired, on the 24th and 25th of February, 1916, and again on the 24th October, on the enemy troops and positions towards Beaumont and Louvemont; the turret gun of Souville fired on Poivre Hill; the turret guns of Moulainville covered the retreat of the troops in the Woëvre from the 25th to the 28th of February, 1916, and then delivered constant harassing fire for several months. The turret gun of La Laufée took an active part in the defence of Vaux from the 1st to the 8th June, 1916.

But, as has already been pointed out, this fighting at considerable ranges was not one of the primary intentions of the guns, since the forts were designed in the first place to ensure the enfilading of the gaps between them. This rôle was never fulfilled, as the enfilading guns were removed at the end of 1915. The importance of the effect of their fire on the approaches to Douaumont, to take an example, can only be surmised.

There remains to be mentioned the defence of the forts themselves.

All the forts, with the exception of Douaumont, captured when ungarrisoned, put up a tremendous resistance. Vaux only fell to thirst, Froideterre stopped the enemy's attack dead on 23rd June, 1916, with the help of rapid fire from its 75-mm. guns, and Souville did the same on the 11th of July, its garrison emerging unharmed from its shelters at the decisive moment. The defence of Verdun was successful owing to its being undertaken along the general line of the forts of Froideterre, Souville and La Laufée, the only places in possession of safe cover. The Fortress of Verdun and the fortified area of the Heights of the Meuse played a most important part in the whole war. They covered and protected the concentration of French troops in that region and, during the battles in the Woëvre in August, 1914, they aided the movements of the French troops. It was to avoid this fortified region, known or believed to be well defended, and behind which the centre of the French Army might be encountered, that the Germans undertook the wide turning movement through Belgium. Verdun acted as a pivot during the French retreat in August and September, 1914, and to enable this retreat to be carried out in safety it was essential that Verdun should remain intact.

German attacks on the centre of the Heights of the Meuse broke down early in September, and again on the 24th and 25th of that month with the small successes of the capture of the fort of "Camp des Romains," the crossing of the Meuse at Saint-Mihiel, and the capture of Chauvoncourt. All attempts to widen the salient of Saint-

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Mihiel made during the war broke down, thanks to the defences resting on the forts of Paroches and Liouville.

Thus Verdun and the Heights of the Meuse contributed largely to the victory of the Marne in 1914, and inflicted an irreparable check to the German Armies in 1916. France, therefore, has no reason to regret the monies spent in fortifying this area. What are 85 to 90 million francs in consideration of the lives saved and the results obtained thanks to permanent fortification? Not even the cost of the War for one day.

ERRATA.

The Reference table (*Legende*) printed under the figures on page 22 (July *R.E.J.*) refers to the figure on page 24, which latter should be described "Underground Plan of" and not "Section through."

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NOTES ON THE CO-OPERATION OF THE INFANTRY AND ARTILLERY OF A DIVISION.

By COLONEL H. W. NEWCOME, C.M.G., D.S.O., R.A.

"Artillery cannot ensure decisive success in battle by its own destructive action. It is the advance of the infantry that alone is capable of producing this result." (*Artillery Training*, 1921, Vol. III., para. 23).

THIS must be constantly borne in mind by the artillery, and the infantry must realise that, under modern conditions, they will be unable to maintain their mobility and offensive power without undue loss, unless their artillery support is effective. An infantry officer recently put the thing in a nutshell when he said that he liked to fight two to one, *i.e.*, with his infantry and artillery against the enemy's infantry. The ideal to aim at is that our infantry should receive the support of their own artillery in the fight and that the enemy's artillery should be unable to help their infantry.

This ideal cannot always be attained, but our object should be to get as near to it as possible and for this the closest co-operation between infantry and artillery is essential. Now it "takes two to co-operate" and each party must do its share. We want to consider the respective duties of the infantry, the artillery, and the commander of the force.

The Commander's Responsibility.—Every plan for attack or defence must be considered from both the artillery and the infantry points of view. The requirements of the two arms are often conflicting, and to make the plan to suit one arm and tell the other to conform does not always result in the most suitable combination of the two. At tactical exercises, the solution often offered is that the infantry will attack over certain ground or take up a certain defensive position and that "the artillery will co-operate," regardless of the fact that efficient artillery support would be very problematical under those particular circumstances. The various methods of carrying out any tactical operation should be discussed by the infantry and artillery commanders concerned, and it then rests with the commander of the force to decide how much weight should be given to the capabilities of each arm and to settle the final plan.

The Artillery Share.—The primary objects of artillery fire are:—(i) to assist the movements of our own infantry, (ii) to prevent the movements of the enemy's infantry (*Artillery Training*, 1921, Vol. III, para. 23). It is therefore the duty of the artillery to ascertain the progress and needs of the infantry and to give them such

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support as they require. To enable them to carry out these duties they must have (i) good observation, (ii) good communications, (iii) good information. *Artillery Training*, 1921, lays great stress on the importance of good observation in all the stages of attack and defence, and this implies good communication between the battery commander at his observation station and his battery. Otherwise he will find himself in the unfortunate position of the officer who, during the retreat from Mons in August, 1914, saw a German battery with its wagons moving across his front at easy range, and could not fire a round because his telephone line had been cut. We must therefore consider observation and communications together, as one is no use without the other.

Increased facilities may be provided in the future for observation from the air and the more universal introduction of wireless telephony may simplify the question of communications, but in the meantime the artillery is largely dependent upon ground O.P.'s and the telephone line or visual signalling. Commanding ground is usually necessary for the first and short distances for the second, so the original selection of ground for attack or defence is an important factor in considering the question of effective artillery support.

In any defensive position there is usually one portion of the ground which gives a more or less extensive view over the scene of the proposed operation; the principal O.P.'s and the guns for the defence of the main battle position should be in this area. Telephone lines may then be short and quickly repaired or visual signalling may be resorted to. If the majority of the O.P.'s are in or near the front line, observation becomes difficult and intermittent owing to the enemy's fire; if a large proportion of the guns are placed near the front line they get in the way of the infantry and are apt to be overwhelmed by the enemy's artillery; it follows that, from the artillery point of view, the infantry should occupy the ground for at least three thousand yards in front of the main artillery position on the high ground, in order to allow of sufficient depth in the distribution of the guns and to secure efficient artillery fire. And from the infantry point of view this appears to be the best arrangement. Although they may be faced with difficulties of supply, carrying out of reliefs, positions for supports and reserves, etc., in the forward position, they can usually find better ready-made obstacles in the lower ground and are better screened from the enemy's O.P.'s and artillery fire. Infantry on the forward slope of high ground make a good target for the enemy's artillery; if they are withdrawn behind the crest, distant observation is impossible and the artillery is very seriously handicapped.

A good example of the advantages of the forward position of the infantry is the holding of the line of the River Ancre by the Third Army in March and April, 1918. The O.P.'s were on the hills north

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of the river, where they had excellent observation over the north side of the peninsula between the Ancre and the Somme, and the guns were close to the O.P.'s The line of the Ancre was held by the infantry where they had the river and marshes in front of them, and where the enemy's artillery had great difficulty in locating them. Various hostile attacks were nipped in the bud as they attempted to deploy from the crest of the hill, and our infantry, weak as they were, had no difficulty in dealing with those which reached the river bank. In fact the principle of two to one was largely obtained in this case.

In the attack the same general principles hold good. The guns must be near good O.P.'s but in this case they should be close up to the infantry so as to cover the advance as far as possible without change of position. The objectives selected should be screened from the enemy's artillery, or our infantry will be shelled off the position, as occurred at Delville Wood. It was not until the attack was continued for one or two thousand yards beyond the edge that we succeeded in holding the wood permanently.

In addition to good observation and good communications brigade and battery commanders require good information both as to the general situation and the progress of the troops they are supporting. It is the duty of the C.R.A. of a division to keep his brigade commanders in touch with the progress made by other divisions on their right and left. To help him to do this, brigade commanders must link themselves up with the main signal centres explained in *Artillery Training*, 1921, Vol. III, para. 142, and the C.R.A. will also employ his staff officers and mounted orderlies; good information from the flanks should thus be secured.

To keep touch with the actual position of the troops in front is more difficult. First it is essential that the artillery brigade commander should be in close personal touch with the officer commanding the infantry whom he is supporting and obtain all available information from him. He should also be in a position to see what is going on from his O.P., and every opportunity must be seized by his battery commanders to keep him fully informed of events passing on their front. But it is often impossible to actually see from the O.P.'s what is going on, so the brigade commander should organize within the brigade a regular system of officers' patrols, which should be given definite tasks and used to keep touch with the headquarters of battalions when required. In addition it will often be advisable for the divisional artillery headquarters to organize a special information party which should be sent out for the day and given a roving commission to gain information by any means which may suggest themselves; special arrangements will be required to enable this party to transmit the information obtained.

These are the principal means by which the artillery endeavour

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to gain the information necessary to enable them to support their infantry.

The Infantry Share.—The needs of the artillery and how far these needs can be met by a suitable selection of ground have been pointed out in the above paragraphs. It is the duty of the infantry concerned to meet these needs as far as they possibly can within the limits of the orders given to them. To be in a position to decide how far they can go in this direction, they must have a knowledge of the difficulties connected with the observation and control of artillery fire, and they will then realize also the disadvantages attending a change of plan at the last moment.

One very important point in this connection is the selection of infantry brigade headquarters and *F.S.R.*, Vol. II, Sec. 107, 7, puts this case very clearly. "To ensure that intimate co-operation between the infantry and their supporting artillery which is essential to success, it is necessary that their respective headquarters should, if possible, adjoin." The artillery brigade commander's choice is restricted as he must be near his batteries in order to control them, so the infantry brigade commander should, if possible, select his own headquarters in close proximity to those of the artillery. These latter are chosen with a view to observation, control, and communication with the division, so that the best positions for the two headquarters usually coincide.

But there is a further duty incumbent upon the infantry, and that is to keep the artillery constantly informed as to their whereabouts and difficulties. In the early days of the war attempts were made to carry out this duty for them by sending artillery *liaison* officers to battalion and even to company headquarters, but it was eventually found that the resources of artillery brigades were insufficient for this purpose. A *liaison* officer must have considerable experience before he can give useful advice to his infantry and must have good communication to his own unit to enable him to convey their requirements to the proper destination; the number of suitable officers, telephonists and linesmen was insufficient to keep the system working satisfactorily on this scale. In theatres of war where the infantry is distributed over a wide front and where the hostile artillery is not very powerful, these considerations may not apply equally; but in normal conditions of civilized warfare it is probable that "the subordinate artillery commander who has been allotted a task necessitating co-operation with a certain force of infantry" can afford only one *liaison* officer with signallers and orderlies. If the two headquarters cannot adjoin, this *liaison* officer must be at infantry headquarters (see *Artillery Training*, 1921 Vol. III, 31). In normal conditions a large share of the infantry in co-operation consists in sending the necessary information back from their front line to their brigade headquarters, where it will be

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picked up by the artillery. To enable them to perform this duty efficiently, a certain knowledge of artillery methods and of practical gunnery is required by all infantry officers. Some of the points which they should study are :—

(i). Method of describing targets. The infantry and artillery must " speak the same language " if they are to work together and any call for fire from the infantry must indicate clearly to the artillery where such fire is required. The clock code with some conspicuous reference point is the normal method of describing targets, but it is necessary that the observer's position should be stated. It has been suggested that the adoption of the aeroplane clock code would obviate this difficulty, but this requires demonstration.

(ii). Moving of guns. Constant change of position means loss of power, as a battery takes a considerable time (varying with the equipment) to limber up, get to a new position, range and get to effective fire. Artillery is powerless when on the move, so all positions should be selected with a view to covering an advance or retirement as long as possible without change of position.

(iii). Allotment of zones. Indiscriminate shooting by batteries over the battlefield may be fatal to effective fire. A German machine gun battery retiring from the Petit Morin in September, 1914, escaped practically untouched in full view of the whole divisional artillery, the reason being that every battery commander started shooting simultaneously and no one officer could distinguish his own ranging rounds. Zones or tasks must be allotted to brigades and careful arrangements made for ranging if a concentration of fire is required.

(iv). Supply of ammunition. Except when time is available for the accumulation of a large reserve, the ammunition available with a battery is very limited, and large barrage or bombardment programmes are out of the question. Infantry officers should bear this in mind when calling for artillery fire. With heavier natures of guns, the weight of ammunition to be handled is also a serious item.

(v). Enfilade fire. This is very effective when it can be employed, but infantry officers must remember that their guns are not then behind them and that communications become long and difficult. They must keep to the programme as the artillery plan cannot be changed at short notice in the middle of the operation. The failure to realise this was the cause of the so-called " short shooting " when the infantry wanted to pursue the enemy after the capture of Beaumont Hamel in November, 1916.

(vi). Range of various weapons. The effective and maximum ranges of guns and howitzers are given in *F.S.R.*, para. 12, 4.

(vii). Effect of various natures of shell, shrapnel, high explosive, gas, smoke, incendiary, etc.

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(viii). 100 per cent. zone. A number of rounds fired from any gun or howitzer even under experimental conditions and with every round accurately layed, will not fall on one spot, but will form an elongated pattern on the ground, the size of the pattern varying with the weapon and the range. The centre of the pattern is known as the mean point of impact (M.P.I.), 50 per cent. of the rounds falling in the vicinity of the M.P.I. In order to obtain effective fire, the M.P.I. must be on or near the target, and this means that a proportion of the rounds must fall short of the target, *i.e.*, in the case of the enemy's front line trench, in "no man's land." Therefore, if our troops are too close to the proposed target, they must be withdrawn to a safe distance or the battery commander will be tempted to place his M.P.I. beyond the target and the fire will probably be ineffective. The shape of the zone also shows the advantage of enfilade fire, especially in the case of a shrapnel barrage.

(ix). Mean point of burst of shrapnel. Infantry officers often used to ask why the artillery were ordered to have a certain percentage of bursts on graze. The reason is the same as in the case of the 100 per cent. zone, *viz.*, that all fuzes at a given setting will not burn for exactly the same time. Fifty per cent. of the bursts will be near the mean point of burst (M.P.B.), but others will burst short or long of this point. The object of ordering a proportion of grazes is to eliminate the short bursts, which are ineffective and tend to prevent the infantry from keeping close up to the covering artillery fire.

Conclusions.—Under present conditions the efficacy of artillery support is largely dependent upon the selection of suitable ground for O.P.'s and battery positions, with sufficient depth in front of this area. The requirements of the infantry and artillery are often conflicting and the relative importance of each arm in any operation is the main factor which must decide the question, always bearing in mind that it is the advance of the infantry which alone is capable of producing decisive success in battle.

It is the duty of the artillery to assist their infantry by every means in their power and to find out their needs by personal *liaison*, observation, patrols, and information parties.

It is the duty of the infantry to make themselves acquainted with artillery requirements and to meet these requirements as far as they possibly can. They must also use every means of sending back to their artillery such information as may obtain for them the support which they require.

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THE ROYAL SANITARY INSTITUTE CONGRESS, 1921.

By F.E.G.S.

As last year, the Council of the R.E. Institution sent a representative to the Congress of the Royal Sanitary Institute, which this year was held at Folkestone at the end of June. The following few notes made at various meetings do not pretend to give any detailed description of the work of the Congress but may possibly contain matter which will be of interest to some officers of the Corps, who if they so desire it can obtain further information on any of the subjects mentioned either through the Secretary, Institution of Royal Engineers, or from the publications of the Royal Sanitary Institute.

President's Address (Engineering and Architecture Section).

In his presidential address to the Engineering and Architecture Section Mr. P. Palmer, M.INST.C.E., said that in the new housing schemes one sees many artistically designed buildings and many inartistic ones. A great deal can be done in the design of chimneys, if well proportioned they can produce a general effect which is pleasing to the eye. One result of the modern conditions in this country is that the skilled craftsman is dying out, there is too little advantage to be gained by the skilled over the unskilled. Further, owing to the call of economy architectural embellishment has too often to be abandoned and utility alone is the prime mover. Only in design is it possible to obtain a pleasing effect and in this the architect and the engineer must work hand in hand.

London County Council Township, Becontree.

Mr. G. Topham Forrest, M.INST.C.E., described the designing of the new London County Council Township on the tract of land in Essex known as Becontree, for 120,000 inhabitants. Referring to cottage construction he said that " after careful consideration of the various methods of concrete construction, including block-making machinery and different kinds of shuttering, it was decided to erect a proportion of the cottages on the first section in the following systems :—

Witan No. 3 *System.*—A hollow-wall system, employing blocks made on the Winget pressure machines, enabling cottages designed for brick construction to be carried out in concrete. The external walls of houses are built 11 in. thick, made up with outer lining

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4⅜ in. gravel concrete—gravel suitable for making a fine quality of concrete was available locally—2¼ in. cavity and 4⅜ in. inner lining of concrete blocks. The cross walls are 9 in. thick, and the ground floor weight-carrying partitions, 4⅜ in. thick, are constructed of clinker concrete. In this system the external faces of cottages will in some cases be rough-cast and in others plain fair-faced blocks and rock-faced.

Composite Concrete Construction System.—This system is a revised form of that originally known as the "Fidler system." The external walls are 9 in. thick, made up as follows:—Outer leaf, 3 in., cavity 3 in., and inner leaf 3 in., both leaves being constructed of clinker concrete slabs and the cavity between them filled with poured gravel concrete. The external surface being of clinker necessitates the application of rough-cast or similar protection. The weight-carrying partitions on the ground floor are also built of blocks. Special hoop-iron ties 1 in. wide, split at the ends and turned up and down to hold the blocks in position to receive poured concrete, are used in this system. Monolithic bands formed at the first floor and ceiling levels give continuous ties round the building, and provide the bearing for the first floor and ceiling joists.

Witan No. 1 System.—Consists of a cavity wall constructed in the following manner:—The thickness of outer slab to external walls is 3 in., width of cavity 2 in., thickness of inner leaf 4 in. Open cavities are provided where floor joists project into the walls, and the adjoining principal wall areas above and below the floor are formed with closed cavities. The through concrete which closes the cavities will also tie the outer and the inner leaves of the wall together. The outer leaf is treated with a waterproofing compound. The cross walls are of 9 in. clinker concrete, and weight-carrying partitions as before. A rough finish to the external face is obtained by placing fibre matting in the moulds before the concrete is poured, giving effect of rough-cast.

Dry Walls System.—A form of poured concrete construction consisting of an inner leaf 5 in. thick and an outer leaf 4 in. thick, the outer leaf being of gravel concrete and the inner of clinker concrete, with a vertical damp course sheeting between the two leaves. Patent climbing shuttering is employed in erection."

In carrying out the work of erecting these cottages the London County Council claim to have reduced many difficulties to a minimum by placing the whole of the work in the hands of one "master contractor."

UTILIZATION OF SEWAGE SLUDGE.

Mr. J. D. Watson, M.INST.C.E., lecturing on "The Utilization of Sewage Sludge" stated that with regard to activated sludge, "If this sludge could be dried and made available as a fertilizer—and under certain conditions it can—the problem of efficient disposal of

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sewage would not be far from solution; but so far, no one has succeeded in freeing activated sludge from water to such a degree that it has become available for manure, and made portable enough to be applied to arable land. The growing knowledge of colloids makes one sanguine that research will be rewarded, and that the nitrogen, which is generally as high as five per cent., will ultimately be utilized and made available as a fertilizer; but, so far, the difficulties have not been overcome. . . ." Many experiments have been made at Birmingham with a humus which is practically identical with activated sludge, and none of them have been successful; ". . . they included an endeavour to filter it through a sand filter built like an ordinary waterworks filter; turning it into long deep trenches and covering it over with dried grass to keep down smell; lagooning it into shallow square plots of gravelly soil; irrigating grass meadows with it; centrifuguing it; pumping it back into the silt tanks through which the sewage passes before it is sprayed over the bacteria beds; but they all failed. The solids and the water emulsify so completely that humus is still like a jelly after lying in shallow lagoons for ten years."

In the discussion one engineer held that de-watering was unnecessary and that the sludge should be piped on to the land. But this opinion met with no support, partly because the land would not require the sludge at all times, and further it was not to be expected that schemes for sewage works would be accepted if they were saddled with expensive pipe systems in addition to their own cost.

The Design of Hospitals.

Mr. E. T. Hall, F.R.I.B.A., gave a most interesting lecture on "The Design of Hospitals," in which all branches of this important subject were discussed by one of the highest authorities on the subject in England. Particular interest attached to the King Edward Memorial Sanatorium at Pontywal, in Breconshire, for 304 beds. "It is of entirely novel construction, permanent in character, without sunk foundations. The contract price before the war, including all engineering, boilers, electric generating plant, accumulators, laundry machinery, kitchen plant, heating, lighting, etc., was about £175 per bed." The single storey rooms were carried on concrete rafts, 6 in. in thickness. Mr. Hall insisted on the psychological value of providing a chapel to every hospital.

Roads in Relation to Health and Prosperity.

In the Engineers and Surveyors Section Mr. H. T. Chapman, County Surveyor of Kent, gave an interesting lecture on "Roads in Relation to Health and Prosperity." After mentioning that his predecessor, Sir Henry Maybury, was one of the first to adopt surface tarring on an extensive scale, he said that "with the increase of

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heavy motor traffic, it became evident that surface tarring of water-bound macadam would not suffice and the use of tar macadam and other bituminous surfacings were extensively adopted." But they were still searching for a waterproof road which would stand heavy traffic. "Whatever type of surfacing is adopted, it is absolutely essential that adequate and compact foundations be provided, and this can be effected in many instances by utilizing the material in the existing road crust (if of sufficient thickness), scarifying and screening the same and treating it with pitch, tar, or bitumen to form a base-coat for the subsequent surfacing or 'carpeting' with a sand and bitumen mixture." In the discussion one member, a Royal Engineer, suggested the use of tins and other iron refuse as a foundation peculiarly suitable to country roads, and the President, Mr. H. P. Boulnois, M.INST.C.E., further pointed out their use as reinforcement for concrete roads. The latter also mentioned a road embankment built up of layers of sludge and clinker, which gave a perfect foundation like concrete. He said that supports to the sides of roads, to prevent lateral splay, must not be forgotten and described how in one case he had laid nearly twenty miles of concrete *in situ* curb with this object.

THE EXHIBITION.

The Exhibition was small but contained many interesting items. Messrs. Doulton exhibited their Eastern native latrine fitting specially designed for the new buildings at Delhi. Their ball valve silencers, porcelain enamelled bib valves, and the Lambeth combination of bath and lavatory basin for small bathrooms are also worthy of mention. The Firth Brearley Stainless Steel Syndicate's exhibit was interesting; and also the London Warming Company's "Kooksjoie" anthracite ranges, one capable of cooking for 300 is said to burn only 18 tons of anthracite in a year. The "Wifesjoie" one-ring gas cooker (Florence pattern) exhibited by the same firm, with water boiler attached, is an extremely economical fitting. The Paterson Engineering Company exhibited their new Chloronome for chlorinating drinking water. This important device is being largely adopted by the Metropolitan Water Board. Meldrum's portable "sack" steam disinfector should be useful on service. Pontifex's rubber composition float, without outside nipple, appears to be a great improvement on copper for ball valves. G. W. Harrison, Jennings, & Woodhead Bros. each exhibited novelties in latrine fittings. The Lacre Closed Circular System Gully Cleanser appears to be a very useful article and well adapted to emptying cesspits.

Among exhibits which did not immediately concern engineers it may be allowable to mention that of the Tintometer, which included their latest effort to design a screen which will produce artificially the full effects of daylight.

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ENGINEER INTELLIGENCE.

By LIEUT.-COLONEL R. P. T. HAWKESLEY, C.M.G., D.S.O., R.E.

THE lecture on Engineer Intelligence delivered by Brig.-General J. E. Edmonds, C.B., C.M.G., on the 17th February, 1920, and reported on in the *R.E. Journal* of June, 1921, is full of interest.

The study of future and current wars by an organization wherein Military Engineers work side by side with the existing Intelligence officers is the only solution.

Engineer Intelligence is as important, neither more nor less, as is every other branch of Intelligence, whether tactical or supply. That it requires Engineers to collect Engineer Intelligence, while any capable officer can, after a short training, carry out other varieties of Intelligence, is the only apparent difficulty which, other points such as funds, being equal, strange as it may appear, cannot be overcome.

To broaden the argument further, I. is a branch of the General Staff and is inclined to devote more attention to what may be termed General Staff Intelligence than to any other branch of the subject. In practice, schemes for operations are brought down to hard bed-rock facts, sometimes, it is feared, from realms of fantasy in the clouds, but more frequently, it is believed, from similar realms on the map, by the stern and practical requirements and limitations of Q. and E. Intelligence is therefore equally important for Q. and E. as for G.

It would be interesting to know what the average business man would think of the following examples :—

1.—During a certain campaign a Brigade of Cavalry accompanied by a Field Troop of Engineers arrived at a damp spot in the sand which was described by I. as " water plentiful."

2.—A certain army was sitting outside and in sight of a certain city for some eight months. I. had issued information as to two wells in the city and in spite of pressure could produce no more information. Nearly at the last moment before operations it was discovered by accident that an enemy officer deserter, lately the borough surveyor of, or who was intimately acquainted with, the city, was at the immediate disposal of I. This officer was hurriedly invited to a Corps Engineer office where he gave every possible information as to all the wells in the city, numbering 20 or 30, which information was eventually found to be correct.

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3.—In a certain campaign maps were issued by I. showing certain roads behind the enemy positions in broad red lines, indicating first-class metalled and bridged roads. High authority ordered, presumably acting on this information, and on arrival in the area, the maintenance of 200 miles of such roads to be carried out by local labour and transport, as neither troops, labour corps or military transport were available. On examination of the situation it was found that :—

(*a*).—50 or 60 miles of these roads did not, in a military sense, exist at all ;

(*b*).—100 miles consisted of a few inches of metal without foundation ;

(*c*).—While the bridges were fair, the culverts were, in nearly all cases, of weak construction.

(*d*).—The population, of whom 50 per cent. had previously died of starvation, were, except for the profiteer class, fit only for famine relief and soup kitchens ;

(*e*).—The enemy had commandeered nearly all carts and horses.

While this sort of thing obtains the position is well-nigh hopeless, the military engineer is forced to bear a cross which could, with ease, be lightened, and operations run the risk of serious breakdown.

The ordinary members of I. cannot help themselves or us, they do their best and are always anxious to help, but, not being Engineers, they are simply incapable of producing Engineer Intelligence.

BOMB-PROOF BREASTWORKS AND PILL-BOXES.

THE following quotations from Mr. Neville Lytton's *The Press and the General Staff* may be of interest to the Corps.

(1) " In the Lys sector most of the trenches were of the breastwork order and such trenches offer little protection from a heavy bombardment unless they are heavily cemented, but we were never the equal of the Germans in ferro-concrete fortifications."

(2) " The pill-boxes were small fortresses garrisoned by about a dozen men ; they were completely *bomb*-proof, and from them the machine gunners could fire in every direction."

J.E.E.

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PROFESSIONAL NOTE.

THE TRAINING OF THE R.E. DISMOUNTED RECRUIT.

(COMMUNICATED BY THE COMMANDANT S.M.E.)

THE following notes on the training of the recruit sapper at Chatham may be of interest.

During the last 18 months recruiting for the Royal Engineers has increased in a very marked manner. This has been due to several causes; firstly, to a systematic "campaign" set on foot by the War Office to stimulate recruiting for the Corps by establishing special recruiting Officers and N.C.O. Recruiters at various industrial and other centres; secondly, by an expansion and revision of the instructions to recruiters all over the Kingdom so as to make much more clear to them the class of qualification required and the standard of proficiency that is likely to lead to acceptance for the R.E.; but most of all by the decision to recruit a much larger proportion than formerly of semi-skilled or unskilled men, *i.e.*, men of the "pioneer" standard.

This last decision has arisen out of the adoption of the principle that the Divisional Engineers of our Field Armies shall in future include in their organization the Divisional Pioneers which in the European War were formed as separate battalions. This entails a greater strength in Engineers in the Division but allows of a considerable proportion of them being of the "pioneer" standard of trade skill. In connection with this change an interesting circumstance is worthy of note. Under the pre-war Pay Warrant "Pioneer" was a *rank*. As long as this condition existed it was found that recruits who when tested in their trade were found not to come up to the standard for the lowest rate of engineer pay, would almost invariably decline to enlist in the rank of "Pioneer." Under the new Pay Warrant "Pioneer" is no longer a *rank*, but it is included as one of the trades in Group E of the list of trades. All recruits can therefore be enlisted in the rank of "Sapper," and when a man fails to fulfil the test for the lowest classification in one of the skilled trades (Groups A—D) he may be *rated* as a Pioneer (Group E). The difference in pay between a Sapper rated as a Pioneer (Group E) and a Sapper rated as a tradesman (Groups A—D) is exactly as it was before, nevertheless directly the change above described was made it was found that nearly every recruit who failed to qualify

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as a tradesman (Groups A—D) willingly agreed to enlist as a Sapper rated as a Pioneer (Group E) and a steady stream of recruits of this type began to come in and has continued to do so. It would appear that the rank of "Pioneer" carried some inferiority of status, or some idea of less prospects of promotion or of acquiring trade skill. At all events the mere change of name has effected a marked difference and indicates the advisability of carefully studying the psychology of the recruit and the young soldier when framing conditions for enlistment.

The result of the increased flow of recruiting was that the strength of the Training Battalion, R.E., went up beyond any peace time precedent and now amounts to over 1,800 of all ranks, of whom about 1,300 are recruits under training, and looks like remaining at about that figure.

This large number has necessitated an overflow from Brompton into a hutted camp on the Great Lines where about 700 are now accommodated. The unfortunate destruction by fire a few years ago of the barracks in the old North Square has raised the question of provision of additional permanent accommodation, since the hutted camp cannot have many years of life before it. It will not be possible, however, to get any decision on this subject until it is decided whether Chatham Barracks is to continue to be the location of an Infantry battalion or not.

The lessons acquired during the War have naturally led to considerable changes in the course of training of the recruits and in the organization of the methods of training. Outside the Corps itself there is often found a belief that the training of the recruit sapper at Chatham consists largely of teaching him his technical trade skill, and senior officers, even of the Staff, have sometimes expressed surprise on learning that skill as an artificer can only be acquired by several years' apprenticeship, and that we aim at getting men who are already skilled at their trade, employing the short time we have them in training them as soldiers.

As a matter of fact, however, an attempt is now made on a small scale to improve the trade skill of some of those who on enlistment fall a little short of the standard. Recruits who, when tested, are not up to the qualification standard, but are believed to be capable, after six months training in the S.M.E. Workshops, of attaining to it, are rated as "Pioneer" (Carpenter) or "Pioneer" (Fitter), etc., and classified as "Fair." At the conclusion of their full recruits' training, application is made, if the accommodation in the shops permit, to the Colonel-in-Charge Records, in the case of such men, to allow them to be retained at the S.M.E. for a six months' course of trade training at the S.M.E. Workshops. Unless urgent demands for drafts prevent it this is done, and in the great majority of cases they improve in skill sufficiently to qualify.

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Nevertheless, the number of skilled tradesmen obtained by direct recruitment from civil sources is still far from adequate to the requirements of the Corps, and with the high wages obtainable by artisans it is difficult to see how it will ever be otherwise. It is probable that the only really satisfactory remedy will be to enlist as many as possible of our skilled tradesmen as boys at fourteen or fifteen years of age and train them ourselves in the same way as the Navy have for many years done for their seamen, and in particular for their Engine-room artificers. A small beginning in this direction has already been made. Some 432 boys are at present under trade training in the Corps, and of these about 134 are under training at Chatham, in addition to 84 buglers, 136 at the Electric Light School, Gosport, and the small remainder at other stations.

This number is quite inadequate, but cannot be increased on account of want of accommodation and of training facilities. A scheme for establishing a Boys' Trade Training Centre for 600 boys in the hutments near Darland Fort has been worked out, and is under consideration at the War Office. The question is bound up with the larger one of training boys as tradesmen for the whole army and cannot immediately be decided. There can be no doubt that such an establishment, attracting as it assuredly would a good class of boy with a good standard of education, and assuming a good system of training not only in handicrafts, but also in general education and of physique, would go some way towards supplying the Corps with tradesmen and with good material for our future N.C.O.'s.

The stay of the sapper at Chatham whilst undergoing his recruit training is some 36½ weeks, of which from three to four weeks are spent on the necessary preliminaries, before a platoon can be formed up and actually launched on the barrack-square; later on, if the time can be spared, it is proposed to add two weeks' instruction in heavy bridging, which will bring the total course to 38½ weeks.

R.E. Recruits are trained in the following subjects:—

Drill,	Swimming,
Musketry,	Field-works,
Gas,	Bombing.

Drill Course.—The drill course includes physical training, semaphore signalling, bayonet fighting, preliminary musketry, section, platoon, and company drill, rifle exercises, extended order, guards and guard mounting, the company and platoon in attack and defence, protection while on the move, in the advance and during withdrawal, and march discipline.

Musketry Course.—The musketry course includes preliminary training, visual training, miniature, classification and field practices, as laid down in Musketry Regulations for R.E., and elementary Lewis gun training. It may be noted that under the latest orders

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the Musketry Courses both for recruits and trained men of the R.E. are identical with those of the Infantry.

Gas Course.—The gas course includes inspection and disinfection, complete protection from the "Alert" and "Normal Slung" positions, gas zones, gas shell training, clearing trenches, methods of entering and leaving dug-outs, and standard tests.

Field-works Course.—The field-works course is divided into two parts, and includes training in earthworks, all kinds of bridging, obstacles, use of spars,, knotting, lashing, and field geometry, camouflage, light railways, slab roads, shelters and dug-outs, concrete work, demolitions, rowing and pontooning, and demonstrations. Further details of the field-works training are given later.

Bombing Course.—The bombing course includes lectures on the construction and use of all kinds of bombs, hand and rifle grenades, practice in throwirg bombs and firing rifle grenades, practice with live bombs and rifle grenades, and practical instruction in trench fighting, both with bomb and bayonet.

A portion of the training in each subject is carried out at night under service conditions, or during the day with use of goggles. The *sequence* of instruction throughout, is lecture, demonstration, practical instruction, test.

During the field-works course Saturdays are devoted to recapitulation in drill and other military training which have already been learnt.

The time allotted to the various subjects is at present approximately as follows :—

Formation, including trial of trade, inoculation, vaccination, clothing, etc.	3 to 4 weeks.
Drill	9 weeks.
Gas	½ week.
Musketry	3 weeks.
Bombing	½ week.
Field-works, Part I	7 weeks.
Field-works, Part II	11 weeks.
Furlough (during courses)	1½ weeks.
	36½ weeks.

The recruit on joining is taken to the Registration Office where his particulars are recorded and thence on to the Company receiving recruits where he is interviewed by the O.C. Company, and issued with a clean shirt, a pair of socks, towel, knife, fork, and spoon, shaving-brush, razor, toothbrush, and a canvas suit; he is given a bath and a hair-cut, draws his bedding and is shown his barrack-room and bed. From this point he is, dependent on N.C.O.'s being available, put under the Section Commander who will put him through his drills. After medical inspection he is tested at his trade, which takes about two days, if successful he is finally approved and given his number. He is then issued with a full kit and necessaries and his clothing fitted by the master tailor. The Company Commander

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then arranges for vaccination, inoculation, and the employment of the recruit either at his trade or at drill or fatigues as may be required until the platoon is formed up. While waiting to be formed up every effort is made to instil the recruit with military spirit, to make him feel that although not in uniform he is nevertheless a soldier, and to teach him to take his place in the military organization of the battalion.

The first step after the formation of the platoon is the clothing inspection, after which the recruit is shown the R.E. Museum and the Headquarters Mess and gets his first inkling of the past deeds of the Corps illustrated by medals and relics, pictures and portraits.

The fundamental principle of all instruction imparted to recruits is the employment in regular sequence of the four methods, viz. :— lecture, demonstration, repetition or practice, test ; whilst keenness and the spirit of emulation are aroused by competition.

A complete record of the recruit's performance at drill, gas, musketry, bombing, field-works, is kept for every man and on the qualifications obtained in each subject is based the final classification of each sapper.

Competitions, with prizes, are held in bayonet fighting, swimming, musketry, and field-works, whilst competitions to determine the champion sections in each platoon are held periodically at drill, pontooning, barrel piering, wiring, etc., etc. Finally an extended series of competitions at drill, field-works, barrack-room discipline, musketry, also sports and games such as football, cricket, boxing, athletic sports, tug-of-war, etc., are held during the quarter to determine the champion company for the ensuing quarter. The champion company, platoon, or section is accorded privileges such as the right of the line on parade, special leave, etc.

The effect of all this is to produce a very high standard of keenness and it has been found that no matter what the standard of knowledge arrived at the recruit is always keen to learn.

On finally completing their courses the recruits are classified as 1st, 2nd, or 3rd class Sappers and the qualification is entered in A.B. 64. To secure a 1st class qualification a man must be keen, intelligent, well educated, of good character, and have obtained 80% of marks in the oral examination.

Education.—All recruits are required to attend school until they have obtained a 3rd class certificate, and after obtaining this they are encouraged to attend voluntarily with a view to obtaining a 2nd and 1st class.

Games.—Although a recruit only stays at Chatham some eight to nine months it is found that men soon acquire keenness in games, and in these, as in military training, everything is done to foster the platoon spirit. Owing to the fact that platoons are constantly coming and going the competitions are generally on the " knockout " principle,

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but league competitions are adopted wherever possible, *e.g.*, in Association football.

There is no doubt that the platoon, party, or squad, for they all mean the same, is the centre round which the recruit's thoughts revolve and is the unit on which he lavishes most of his *esprit de corps* as in the school the small boy's ambition is to play for his house ; but afterwards when he is good enough to play for the school he begins to realize and incidentally grafts *esprit de l'école* on to his *esprit de la maison* ; so in the Training Battalion, the recruit whilst gradually acquiring *esprit de corps* never loses his *esprit de peloton* and it is the latter, acquired in the right way, which is the foster-parent of the former.

The O.C. of a Recruit Company is necessarily much occupied with administration and it is mainly to the platoon officer that the recruit looks for advice and assistance. The principle which is aimed at and as far as practicable carried out is that the Platoon Commander (an officer), the Platoon Serjeant and the four Section Commanders are in charge of the Platoon from the day of its formation to the day it finally completes its course, and that they are responsible for the whole of its training and for everything connected with its administration, health and comfort, sports and games. In the majority of the subjects the Platoon Commander himself carries out the training under the general supervision and co-ordination of the specialists in each subject, *e.g.*, the Major in charge of Field-works, the Musketry Officer, etc., It is only in the first course of drill on the Square that the instruction is actually given by the staff of Drill Instructors under the Adjutant, but the Platoon Commanders are always present, watching the progress of their commands. Also in general education the preparation for school certificates has still to be carried out by personnel of the Army Educational Corps.

This system requires an officer for every platoon, and with recruiting at its present rate it is not always possible to provide one. To admit of it platoons are formed as strong as possible, *i.e.*, from 60 to 80 recruits, but even then the number of officers available seldom permits of every platoon having one. Where no officer is available a selected warrant or non-commissioned officer is placed in charge of the platoon and exercises the same functions.

It is impossible to over-estimate the enormous advantages which have accrued from the present system, and the necessity for its continuance, which will only be possible if the officers are forthcoming, as it is sincerely hoped they will be. Not only in work but also in games the platoon subalterns work with their men and give up practically all their time to and for their men. The result of this and the effect of this system on the recruit cannot be put into words, but anyone who has charge of training knows that it is the right system;

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it is the system which made our armies in France and which will make our armies in the future.

Syllabus.—This is laid down in "Syllabus of Training, R.E. Dismounted Recruits, Military Duties" issued with W.O. Letter 27/Gen.No./7592, and the portions affecting field-works are extracted below. To the syllabus has been added the name of the field-work ground where each portion of the training takes place.

PART IV.—PRELIMINARY FIELD-WORKS.

Subject.	*Lecture.*	*Days.*	*F.W.Ground.*
Use and care of Tools	1	3	Darland.
Brushwood	1	3	
Obstacles	1	5	
Earthworks—Trenches, revetting, revetting frames, trench boards, field level and field geometry, experimental, and filling in	6	13	
Knotting and Lashing (distributed by hours)		3	Upnor.
Bridging—Barrel piering, trestle and light bridging, pile driving, improvised bridges	4	8	
Camping arrangements and water supply	2	2	
Blocks and Tackles	1	2	
Examination		1	Barracks.
	16	40	

PART V.—ADVANCED FIELD-WORKS.

Earthworks — Camouflage, M.G.E.'s, O.P.'s, concrete shelters, dug-outs, mining, defence of localities, siting of trenches	6	17	Darland.
Light Railways, slab roads, and overland tracks	2	4	
Demolitions	3	6	Ravelin and Darland.
Heavy Bridging	2	8	Ravelin.
Pontooning	2	14	Upnor.
Examination		1	Barracks.
	15	50	

The total course is 90 working days which, at five days a week, makes it extend over 18 weeks.

	Hours.		
	Summer.	*Winter.*	*Remarks.*
Monday	0730—1600	0800—1600	Lunch on the work, three quarters of an hour allowed.
Tuesday	0730—1600	0800—1600	
Wednesday	0930—1600	0930—1600	Dinners in barracks at 1630.
Thursday	0730—1600	0800—1600	
Friday	0730—1315	0800—1315	Dinners in barracks at 1330.

Object of Field-work Training.—The object is to continue the recruits' education as a soldier and to cultivate his soldierly spirit as well as to ensure he has a thorough grounding in the subjects named in the syllabus.

Field-work Platoons.—The training is carried out in platoons. Strength of platoons from 60 to 80 recruits. Each platoon is commanded by a subaltern officer who is responsible for its training and is excused as far as practicable all company, regimental, and garrison duties which interfere with the hours of training. To assist

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the Platoon Commander a Q.M.S. Instructor in Field-works is detailed from the Fortification School. And there are the platoon sergeant and four section commanders. These latter N.C.O.s are available for regimental duties, but every effort is made not to change the section commanders if it can possibly be helped.

Field-works Major.—A Major is borne on the establishment of the Training Battalion to superintend field-work training. He has a whole-time officer assistant who is responsible for the continuity and superintendence of platoons at the Darland Ground; and a part-time officer assistant similarly assists at Upnor and the Ravelin. A senior Q.M.S. Instructor in Field-works, a draughtsman and an N.C.O. i/c Darland Dump complete his staff. He issues orders as regards Field-works direct to Platoon Commanders, keeping Company Commanders informed. He is responsible for keeping instruction up-to-date, for keeping in touch with the Fortification School to prevent clashing with officer and other classes, for keeping track of each individual recruit, in order that he may receive the full instruction, and for general superintendence. He issues orders to Platoon Commanders on Fridays for the following week's work.

Lectures.—These are given by the Platoon Commanders or the Q.M.S. Instructor with the platoon. Platoon Commanders are issued at the commencement of the course with a detailed synopsis of the lectures. No lecture is to be longer than three quarters of an hour. Lectures are given when the men are fresh, immediately after leaving the morning parade and before commencing work.

Note Books.—The men are issued with these and it is left to the discretion of the Platoon Commander as to what use he makes of them. The men are not marked on these note-books but on the results of the oral examinations held at the end of Parts 4 and 5.

Examination and Classification.—At the end of Parts 4 and 5 each recruit in a platoon is examined orally by a Board of Officers and is marked. In addition a report is obtained from the Platoon Commander as to a man's keenness, smartness, ability to work, and on the combined result of this and the oral examination each man is classified as *Excellent, Very Good, Good, Fair,* or *Indifferent,* and this classification is entered up on the Platoon Classification Sheet. Indifferent men are put back for further instruction.

Sequence of Training.—This usually follows the order given in the syllabus. An occasional variation is sometimes required to fit in with other training, but to keep to the same sequence greatly expedites dealing with casuals.

Casuals.—These unfortunately occur owing to sickness, put-backs, punishments, etc., and they are placed in a new platoon according to the progress they had made before becoming casuals.

Dress.—Drill order in canvas with canteens.

Night Work.—Dark goggles are used to produce the effect of night

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and the training is carried out during the usual hours. Wiring, digging, revetting, and pontooning are practised in goggles.

Box Respirators.—These are carried on Fridays, and the platoons wear them for periods varying from 10 minutes up to two hours according to the stage of training. The normal work is carried on while wearing them.

Use of Tools.—Great attention is paid to the proper use of the pick and shovel. A drill has been devised and the men are taught by numbers as they are taught the rifle exercises. Practice in this drill is given for short periods throughout the course. Task work is also given at intervals in order that the men may realize their progress.

Darland Field-works Ground.—A trench system has been developed with its trenches, shelters, mined dug-outs, machine gun emplacements, observation posts, etc., etc. This gives an opportunity for every section of every platoon to construct all types of revetment, to see other work that they may not be able to do and gives them the feeling that they are constructing, not merely doing something which will be pulled down. The necessary materials are obtained from a dump near the site of work.

Competitions.—In the platoon section competitions are arranged in wiring, barrel-piering, pontooning, and rowing, and at the end of the course all the men of the best section are presented with prizes by the Commanding Officer. Times are kept in the competitions and in that way platoons can be compared with one another.

Best man in Platoon.—At the end of the course the eight best men of the platoon chosen as the results of examinations and platoon commander's report are presented with prizes by the Commanding Officer, and the best man receives the Haynes Memorial Medal.

General.—The utmost is done to make the training real and interesting to all concerned. The Platoon Commander is really responsible for the training of his platoon and is not taken away on petty side issues. If he makes his platoon better than others he scores marks towards the Champion Company of the Battalion. The Section Commander is with his section and has an incentive to make it the best section in the platoon. The best section is allowed a number of privileges. The individual man has his section to work for and also the individual prizes. The result is that each recruit gets good training in field-works and also becomes a good soldier with great pride in his Corps, Battalion, Company, and particularly his Platoon.

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REVIEW.

TREATISE ON AIR SCREWS.

By WHYRILL E. PARK, A.R.C.Sc. (Chapman & Hall. 1920. 21/-).

This very technical and exhaustive treatise deals with the mathematical principles involved in the design of aircraft propellers. The principal problems investigated are :—(*a*) The thrust developed by a propeller ; (*b*) The stresses produced in the same under given data. It is scarcely necessary to say that such problems are highly difficult and complex. The work is a mine of information in the field which it professes to cover.

J. M. WADE, *Lieut.-Colonel.*

NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 47.—*Summary of the Military and Political Situation.*—The difficulties of France in raising her Army are appreciated. The *M.W.B.* does not think her yearly recruit class will amount to more than 200,000 men, which, with 18 months' service, only gives a peace strength of 300,000. The remaining 460,000 have to be made up of volunteers, re-engagements, and, above all, coloured troops. But, as the *M.W.B.* bitterly remarks, the utter defencelessness of Germany makes it a matter almost of indifference to her, what the figures may be. While France is budgeting for 33 milliard paper marks, Germany can keep all the army she is allowed to for three milliard. Poland's action over Silesia is, of course, remarked and Mr. Lloyd George's speech does not give much comfort, because, says the writer, he has so often led simple Germany into a trap. In S.E. Europe French influence is said to be on the upgrade. Belgium's army, temporarily fixed at 100,000 men, exclusive of officers and colonial troops, is said to be too small and too little trained for French ideas ; since Belgium must be relied on to stand side by side with France, when action against Germany is contemplated. The acceptance by Germany of the Allied Ultimatum has left the writer in a very pessimistic mood. Above all he is disappointed in Mr. Lloyd George, and asks if anyone will now doubt that Albion is perfidious.

The Mission of Lieut.-Colonel Hentsch and the coup-de-main at Liége in 1914.—Lieut.-General Schwarte contributes some interesting remarks on these two subjects. As regards Lieut.-Colonel Hentsch, he says that the conference, which concluded with his despatch, was attended by von Moltke, Colonel Tappen, Lieut.-Colonel Hentsch and Colonel (now General) von Dommes. The latter declares that von Moltke, fearing that the commanders of the 1st and 2nd Armies did not, on September 8th, 1914, properly appreciate the situation, and in consequence were inclined to retreat instead of holding on, decided to despatch Hentsch, and gave him the following verbal orders :—" Go to the headquarters of 1st and 2nd Armies and stop them beginning any withdrawal (*und verhindern Sie dass dort rückgängige Bewegungen angetreten werden*). If you do not arrive in time and a withdrawal has already begun, direct the inner flanks

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of the Armies on Fismes." General von Dommes regrets that he did not at the time write down the words used, but declares that he has so often recalled them that it is out of the question that he can be mistaken. The conference, which was very short, took place in the forenoon of September 8th, 1914, in the Schoolhouse at Luxembourg. General von Schwarte says that it is established that when Hentsch reached 2nd Army headquarters no withdrawal had begun. General von Bülow's report shows that he explained the situation to Hentsch and announced his intention to retire, which Hentsch agreed with. The latter does not appear to have fulfilled his instructions to prevent any withdrawal being commenced, for von Bülow would certainly have mentioned such a thing in his report. Whether Hentsch would have succeeded in making von Bülow change his mind cannot be stated, but von Schwarte considers it clear that Hentsch did not fulfil the first part of his orders, and consequently must bear a great part of the responsibility. He allowed himself, already pessimistically inclined as he was, to be influenced by the still more pessimistic atmosphere of 2nd Army Headquarters, and then, when he got to 1st Army Headquarters had to announce that the 2nd Army was withdrawing.

As to Liége, he says that it is incorrect to attribute the project of the *coup-de-main* to Ludendorff. It was von Moltke who was responsible for the idea, for he in 1906 decided that, in accordance with the Schlieffen plan, Liége must be quickly captured, if Dutch neutrality were to be respected. The plans were accordingly all worked out in the greatest detail years before Ludendorff went to the Operations Branch of the General Staff. It only remained for him to keep them up-to-date, and see that the necessary troops were told off. The commanders of the six assault columns were naturally not so well aware of the vital importance of their task as was Ludendorff, who had for years worked on keeping the plans up to date. Therefore, when the commander of the 14th Infantry Brigade was killed, Ludendorff being at Montjoie with the Headquarters of the 2nd Army, was able to appreciate the critical nature of the situation. Acting with the utmost energy, he took command of the Brigade and personally led it to victory. The cause of the failure of the other five columns told off for the assault is, so far, not known. To Ludendorff is due the credit for the actual capture of Liége, but not for the plan.

Comparison between the present German and Austrian Establishments of Officers.—The establishments have been fixed as follows :—

	Germany.	Austria.
Generals and Lieut.-Generals	17	11
Major-Generals	28	25
Colonels	110	134
Lieut.-Colonels...	200	321
Majors	400	249
Captains and Subalterns ...	3245	670
	4000	1500

No. 48.—*Attack on German Corps of Officers.*—The paper *Freiheit* has attacked the pre-war Prussian officer in the following terms :—" The Prussian officers before the war constituted the scum of the

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nation. They were stupid, brutal and quite unmoral. Their conception of honour and duty placed them below the level of dogs. Their sole idea of ethics was summed up in standing strictly to attention before their superiors, and they had made no progress since the middle ages. The 2,500 milliards that the Entente has charged Germany for ridding her of this pest is not too high a price . . . " and so on. The *M.W.B.* points out that the losses sustained by the Officers' Corps form in themselves sufficient refutation of these calumnies. 40 per cent. of the officers who were on the active list in 1914 were killed and 24.6 per cent. of all officers on the active list between the outbreak of war and 1st January, 1919. On the other hand only 15.4 per cent. of the other ranks fell during the same period. The *M.W.B.* regrets that previous experience has shown that legal action by the Officers' Association against such libels is almost certain to be useless.

No. 49.—*South Eastern Europe.*—The writer says that in spite of the policy of the " Little Entente " having been originally directed against France, the predominant influence in S.E. Europe is French.

Checko Slovakia.—The organization of the army is not yet complete but its peace strength is placed at 180,000 men. The Chief of Staff is French and many important positions are filled by French officers, which, when taken with the distribution of the Army, indicates that offence and not defence is contemplated. The greatest number that can be mobilized is 1,750,000 men, forming 12 active and 24 reserve divisions. The army has not been placed beyond the reach of politics. Of the returned legionaries no less than 18,500 have been incorporated in the peace army.

Jugo Slavia is preparing a new defence law which will cover all men between 21 and 50. She has at present 190,000 under arms, *i.e.*, five yearly classes. Discipline in the Croatian and Slovene contingents is not so good as in the Serbian. The disposition of the Army shows that it is directed against Albania, Greece and Bulgaria.

Greece has fully half her army in Asia Minor, driven thereto by England.

Bulgaria has an army of 20,000 with 60 guns and a gendarmerie of 13,000 mostly mounted, and organized on a military basis.

Roumania is still negotiating with Russia, but appears to have come to an arrangement with Poland, in case of an attack by Russia. The deplorable railway situation would render any mobilization or troop movements very difficult. Out of the 23 Infantry Divisions eight are on the Dniester and in Moldavia ; six are in the Dobrudja and in Wallachia, the remainder in the Siebenburg mountains.

Hungary.—Thanks to Karl's unlucky coup, the Hapsburg hopes have been dashed, and with them the hopes of a Danubian alliance. These were backed, unofficially but in influential circles, by France in order to erect a barrier against German expansion to the south east. The common danger from the Bolsheviks has driven Hungary and Poland together, for the time. Politically and economically France has a strong position and works against Germany whenever she can. The reduction of the Army from 130,000 men to the permitted 35,000 is in hand.

Austria is in every way the weakest State, and will almost cease to

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exist when France has done with her. Thanks to the absurd Soldiers' Council *régime*, the Army is more of a danger to the State than a support.

The Demolition of the Wireless Station at Kamina in Togoland in August, 1914.—The Kamina station was only completed a short time before the outbreak of war, and though only a few messages came through it for Togoland itself, it proved invaluable as a transmitting station. A message from the German Admiralty to a cruiser arrived *via* Nauen, Kamina and Windhoek in German South West Africa, in 10 hours. As soon as the outbreak of war was known in Kamina on 2nd August, all German Colonial Governors, merchant and warships within range were notified; the cruisers *Königsberg* and *Eber* being thus warned. In the early days of August, no one thought that hostilities would be extended to Africa, and in any case a successful defence of the wireless station was out of the question. Soon, however, it was seen that it would have to be demolished and after it had dealt with a mass of telegrams coming from South America *via* Duala for Germany, it was destroyed on the 25th August, shortly before the approach of the enemy.

England's Great War Crime.—Before the war Germany was the best-fed country in Europe, but the blockade changed all that. German losses in the field amounted to 1,822,545 of all ranks killed and died of wounds and disease. Her losses through the blockade were far heavier. Her pre-war scale of living allowed a daily average of 2,400 calories per head, but by April, 1917, this had been reduced to 1090. Lack of fats caused great increase of all illnesses, and 30 years' work against tuberculosis was undone. In so far as the damage due to the blockade can be put into terms of money, it is estimated to amount to 56 milliards of marks.

No. 50.—Major-General Waechter gives a long review of Colonel Bruchmüller's book on artillery in attack. The gradual development of the creeping barrage is traced and the difficulties met with in organization are dealt with. Much of the failure of the Rheims, 1918, attack is put down to over-centralization of artillery command, whereby the divisional commander had nothing left in his hands.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE SUISSE.

No. 2.—*February*, 1921.

A Scheme for the Reorganization of the Swiss Army.—In the original article Colonel Sarasin gives an outline of the army reorganization scheme prepared by the Swiss General Staff and approved by the Commission for National Defence. The scheme aims at increasing the machine gun armament of infantry and cavalry regiments and in bringing the artillery armament into line with modern requirements, *e.g.*, the present field guns are to be replaced by guns having a range of at least 10 km., and firing a shell of at least 10 kilos. in weight; by providing mobile trench mortars; and by increasing the number of howitzer batteries. The training period for recruits and "young officers" is raised to 85 days. On the completion of this course 25 per cent. of the young soldiers—chosen from among those who are required in the civil branches of the public service, and those who show small aptitude for the military

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profession—are to be permanently transferred to the Reserve; they will only be called up for further military duty in a national emergency. The remaining 75 per cent. of the young soldiers will, under the proposed scheme, be posted to the Élite, and will be called upon to go through five annual trainings, each of a duration of 20 days. On reaching the age of 28 years, the trained soldiers will be transferred permanently into the landwehr.

A New Book on Marshal Foch.—The original article is a review by Colonel Fonjallaz of a book entitled *Foch: Essai de psychologie militaire*, by J. R. (Payot, Paris, 1921, at 6 francs). The view is expressed that, in his conduct of the latter part of the Great War, Foch showed that he possessed a genius in which were combined the striking features of the genius of those two great Captains: Napoleon and Moltke.

NOTES AND NEWS.—*Switzerland.*—The demand of the Socialist Party for the abolition of the military code and trials by court martial in Switzerland has been rejected by a large majority of votes. It is announced that the Federal Council proposes to recommend a modification of Article 77 of the Law relating to the organization of the army. This Article provides that the cavalryman shall have reimbursed to him one half of the price paid by him for his horse; it is hoped by this means to effect a saving of half a million francs on the Army votes.

France.—A Special Correspondent deals with a book entitled *Réflexions sur l'art de la guerre* which is attracting a considerable amount of attention. Owing to the Ministerial decree forbidding officers of the French Army to publish their writings, the author of this work has had to hide his identity under the symbol XY; he is a distinguished general who held a very important appointment on General Pétain's Staff during the War.

Portugal.—A Special Correspondent furnishes a few details relating to the new organization recently introduced into the Portuguese Army. The annual levies of recruits will join the infantry in two contingents, namely in January and May of each year; in the case of the other arms of the service the recruits will join their depôts once in the year only. The period of training for recruits will vary according to the requirements of each branch of the service. Military service will be on a Militia basis; on the completion of the recruits' course, the permanent cadres will alone be retained with the units whilst the majority of the young soldiers will return to their normal occupations. The men in the ranks will subsequently undergo seven annual trainings of from 15 to 20 days—in camps to be formed in September of each year. The men required for the permanent cadres of units will be retained for service with the colours for periods of from 18 to 24 months after the completion of their recruit's course. The retention of trained soldiers in the permanent cadres, it would seem, is held to be necessary as a precautionary measure to meet the contingency of Bolshevist disorders. In an editorial note it is pointed out that the mobilization of an army is a most efficient method of coping with a Bolshevist rising; the adoption of such a course enabled the Portuguese Government to suppress such a rising within three days of its outbreak, and without the loss of a single life from acts of violence.

W. A. J. O'MEARA.

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WATER SUPPLY TO ARMIES IN THE FIELD.

By LIEUT.-COLONEL R. P. T. HAWKESLEY, C.M.G., D.S.O., R.E.

IN November, 1919, *The R.E. Journal* published an article on "Water Supply of Troops in the Field." This was written by myself very shortly after the Armistice with a view to recording some of the experience in this important subject which was acquired during the campaign in Palestine. The present paper may be taken as amplifying the former.

I wish, in the first place, to bring to notice certain details which are not mentioned, not correctly mentioned, or not sufficiently mentioned in the text books; and in the second place to describe in narrative form the measures, as I visualize the subject, which would be taken by the administration under the various circumstances which would occur in a more or less normal campaign.

I propose, for this purpose, to assume that the campaign is being fought successively over four distinct classes of country as follows:—

(i).—A base, which is plentifully supplied with water from shallow wells of large capacity.
(ii).—A tract of desert country some 50 to 100 miles in width.
(iii).—An extent of country where deep wells only are found.
(iv).—A country of running water, streams, rivers, and springs.

In order to bring out the points in connection with water supply as fully as possible I will assume that we are continually advancing, except when stabilized periods assert themselves, and that the enemy is first met with at the far end of the desert tract, and will not attempt to describe engineering details exhaustively.

The troops operating on our side will be assumed as one Corps of three Divisions and one cavalry Division, with L. of C. troops and a labour organization, giving a grand total of some 90,000 men and 30,000 animals. This assumption is made in order to enable the work of the higher Engineer directorate to be discussed. The actual constitution of such a force does not affect matters of principle to any extent, but the water operations for quite a small force would differ considerably from those described here.

The supply of water to an army in the field is as essential as are supplies and munitions. Owing to its weight of 10 lbs. per gallon water cannot be economically carried by road except in very small quantities, such as in water carts or where special measures are

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taken for special operations. It can only be carried in large quantities under great difficulties and at great cost by rail. A military railway is invariably more than fully occupied in the transport of troops, supplies, munitions and the necessaries for the railway itself, so that there is rarely any room to spare for water for the troops.

A soldier is a fighting athlete and should be brought up to his highest state of physical efficiency at the moment when he goes over the top, and from that point his efficiency should be maintained at its maximum, as far as is possible, until the end of the war. Failing an efficient and sufficient water supply, this condition cannot be ensured. It is highly undesirable to allow any training in reducing the consumption of water. The idea that men and animals can be trained to drink or use less water and maintain their efficiency is based on a complete fallacy.

The supply of water to troops in the field is a purely engineer proposition—but "Q" is responsible for the administration of the water areas. The supply of water to a large force in the field is quite as difficult and scientific a proposition as is the supply of water to a city of a similar number of inhabitants. The headworks may not be of such magnitude and the distribution may not be so complicated as those required by the latter but this is offset by the mere fact of the wide distribution of sources, of, frequently, unknown capacity, the uncertainty of tenure and the speed at which supply must be given. The supply of water must be as generous, within economic limits, as the skill of man can devise.

The actual requirements are as follows :—

Men.—One gallon per day for drinking and cooking. This is the allowance during operations. This amount should, if possible, never be reduced, although cases have occurred when a ration of half a gallon per day was essential for short periods. In addition men require a minimum of four gallons per day for ordinary washing and a further addition of as much as can be economically provided for disinfecting, bathing, washing clothes and other purposes. An allowance of more than one gallon per day must be given, as above, in stabilized positions and on L. of C.

Indian troops always require more for washing purposes than British troops.

Horses and Mules.—Ten gallons per day, but in very hot weather they often drink 12 gallons per day. This is given in three waterings, after sunrise, at noon, and in the evening before sunset.

Donkeys.—Eight gallons per day in three waterings.

Camels.—Fifteen gallons every third day. In very hot weather a camel will drink upwards of 20 gallons. Twenty minutes should be allowed for watering each animal. If camels are watered more frequently than every third day, they lose their normal ability to last three days without water.

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Oxen.—Eight gallons per day. It increases efficiency if oxen can have free access to open water. Troughs for oxen should be free of lashings, etc., which entangle their horns.

The efficient and quick watering of men and animals depends on two main points :—

(*a*).—The efficient and quick supply of water from the source to the water area and

(*b*).—The organization of the water area.

A water area consists of two parts, firstly a parade ground to which free access is required from the camps, and an enclosure in which tanks, troughs etc., are erected, and from which egress must be easy. If these conditions do not exist near the source of supply and time allows, it pays to pipe the water to a site where these conditions obtain. A congested water area prevents efficient organization and re-acts on the efficiency of the force, and much more so on the temper of all concerned. From the parade ground water carts and animals pass into the water enclosure, which should be fenced and policed. The water carts pass, in turn, to the standpipes, and the animals in batches to the troughs. The animals should fill up the trough from the far end. As each batch finishes watering it should be turned towards the exit and marched off clear of the exit.

It is desirable to provide a trough specially for the horses of staff officers and others who are in a hurry.

Camels should never be allowed to use the horse troughs, but should be provided with separate ones at a distance from the horses, or better still, with a separate water area at a distance from that used by horses.

The number of standpipes should be calculated in the usual manner, in accordance with the speed of supply of water.

The number of troughs should be calculated, jointly, in accordance with the speed of supply of water and at the rate of 180 horses or 54 camels per hour, using both sides, in the case of troughs, waterproof, canvas, 600 gallons (33 ft. long), or their equivalent in timber or masonry. The lay-out of the water enclosure should be on a generous scale. The spacing of troughs in the clear should be not less than 30 ft., and roadways should be on the wide side.

Water should be delivered to the troughs and standpipes through pipes, whether iron or hose. It is usually the case that a reserve of water must be provided in the enclosure, and therefore tanks must usually intervene between the source and the troughs and standpipes. One or more of such tanks would be used for the chlorinating of drinking water. These tanks are, in the early stages, as a rule " Tanks, waterproof, canvas, 2,300 gallons," but, if a stay of any duration is expected, they should be replaced by tanks in wood, iron or masonry, as should the troughs. The supply from the tanks to

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the troughs may be by hand L. and F. pumps, but it is better, unless pumping by hand is in any case deliberately considered as a means of physical training, to avoid the labour entailed and substitute small power land pumps or to site the tanks and troughs so as to make use of gravity.

In the case of gravity supply from canvas tanks, a connector in the bottom of the tank should be fixed as a part of the equipment of the tank, and the water led thence by iron pipe or by suction hose in the early stages to the troughs. Tanks are not now issued fitted with connectors as above described.

The supply to the water carts may be by hand L. and F. pumps, by power pumps or by gravity to standpipes.

Troughs, if of canvas or wood, should as soon as possible, even for temporary occupation, be protected from the rush of thirsty animals by strong guard rails. No amount of orders, regulations and discipline will prevent this rush.

Tanks, waterproof, canvas, 2,300 gallons, only hold about 1,500 gallons, and troughs, waterproof, canvas, 600 gallons, only hold about 350 gallons. It is desirable to alter the nomenclature, and it would be interesting to ascertain how the registered contents were originally arrived at.

When long troughs are provided the delivery of water must be sufficient in quantity and must be at several points at one and the same time, otherwise the animal at the near end gets all and the animal at the far end gets his watering but no water. The distance between deliveries may be 33 ft., which is the length of a trough, waterproof, canvas, 600 gallons. This trough may be taken as the unit.

An efficient water officer, appointed by "Q," should be in command of each water area. He should have a good command of language suitable for all ranks. None but officers inspecting, such as the Divisional Commander, C.E. and C.R.E., should be allowed to ride into a water area—all others, including general officers, should be made to dismount and lead their horses.

Small land power pumps used for distributing to troughs in a water area can be provided with a portable hose distributing system quite efficiently.

Troops in the field may, for water purposes, be considered as organized in Brigade groups. A Division therefore may, for water purposes, be considered as constituted as follows:—

			Gallons per day.		
	Men.	Horses and Mules.	Men.	Horses.	Total.
Divl. H.Q. group ...	3900	3120	3900	31200	35100
3 Brigade groups (each)	5000	1530	5000	15300	20300

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These figures show the minimum requirements with men at one gallon per head per day and are approximate for an Indian Division, but are near enough for water purposes.

A British Division is somewhat weaker in animals and requires somewhat less. Corps troops vary in number, but may be roughly taken at 10,000 men and 5,000 horses and mules. For each group one or more water areas, according to the sites of camps and yields of water from the various sources, must be provided.

Water supplies may be conveniently considered as under two main headings :—

(*a*).—For troops when at rest or in a stabilized position or marching on a L. of C. or in preparation for operations, and

(*b*).—For troops when operating.

The scarcer water is, the more appliances are required for handling it. This appears to be a paradox, but is painfully true in warfare. The pre-war establishment of water gear with a field company was apparently limited to four pumps L. and F., with no tanks and troughs. The number of field companies with a Division was then two. How the 6,000 animals of a Division, with its 20,000 men, could be efficiently watered with this amount of gear, even at the openest of open water, is difficult to understand. It is hoped that more attention will be paid to the subject in respect of the post-war establishments.

In the Palestine campaign, which may be considered as more or less normal, the establishment per field company was :—

12 pumps, L. and F.,
4 tanks, waterproof, canvas, 2,300 gallon,
12 troughs, waterproof, canvas.

and each H.Q. Divisional Engineers carried two engines and two power pumps each, capable of 1,000 g.p.h. against 150 head. Each Field Company carried in addition a number of waterbag sets, of which more hereafter. Whenever possible and necessary, units should be provided, at their camps, with tanks to hold the water brought to them from the water area.

Before the commencement of a campaign the Engineer-in-Chief should be in possession of all facts concerning the water supplies and kindred subjects in the countries in which the campaign will take place. This information should have been collected by the Engineer officers of the General Staff (Intelligence) who will have studied the present and other campaigns. As a matter of fact it is doubtful if such Engineer officers exist, or whether any Engineer intelligence has ever been collected for any campaign prior to the commencement

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of that campaign, by Engineers. General Staff officers cannot be expected to collect such information and only Engineers can obtain the information they require, and only Engineers know from whom to extract such information and how to extract it. The result has been that Engineer intelligence has been indifferent. This applies not only to water but to all branches of military engineering.

It can be laid down as a basic condition that, unless the water situation of a proposed campaign as reported by Intelligence is satisfactory, the campaign either will be difficult or cannot be carried out. The Engineer-in-Chief having thus these facts as regards the campaign at his disposal and having in view the sources of water and the likely duration of the campaign, will be able to decide, as regards the four different phases of the campaign, on what lines estimates should be made for :—

(i).—Classes of pumps and pipe lines.
(ii).—Numbers of water stores of every description, such as pumps, L. and F., troughs, tanks, etc.
(iii).—Alterations in the equipment of Field and other Companies.
(iv).—Alteration in the establishment of Field and other Companies.
(v).—Establishment of machinery parks and shops, which must be efficiently controlled and manned.
(vi).—The establishments for working enemy workshops or civil workshops which will be encountered in enemy country.
(vii).—The raising of special companies for water purposes,

and, in general, will be able to visualize the water situation throughout the campaign.

The Engineer-in-Chief would consult the Commander-in-Chief and obtain from him a definite decision as to any large schemes which may be necessary.

It must always be remembered that campaigns are directed by politics and that it is in consequence very rarely the case that definite orders can be obtained, even by an Engineer-in-Chief, such as will enable him to budget completely, very far ahead.

The information gathered by the Engineer-in-Chief would be, as far as is desirable, transmitted to Chief Engineers and C.R.E.'s, with his views, in addition to receipt by the latter of the ordinary Intelligence reports.

In due course the Army will arrive at the base and will in such an area, where shallow wells occur, provide itself with water without much difficulty, using the company equipment, but in this case and all other cases the company equipment proper, should, wherever possible, be substituted by other equipment and the company equipment should be withdrawn and prepared for operations. As shallow

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water is liable to pollution it is essential that the engineers shall work in close touch with the military medical authorities, and this close touch should be maintained throughout the campaign.

If the country is malarious special arrangements will have to be made for protecting the sources of all water from mosquitos. This, however, is another subject and cannot be dealt with in this paper.

It is probable that the machinery park and shops will be established at the base, and it is desirable that all machinery issued should be properly recorded and supervised from the first. Engine logs and history sheets should be instituted and should not be allowed to fall into disuse.

Salvage organizations should be formed for salving machinery and other water stores from water areas and sources to be abandoned by formations about to advance. These salvage operations should be carried out in such a manner as to relieve the Engineers of the Formations of the responsibility and the labour of salving and returning to store at the last moment before a move takes place.

The field engineers of the Chief Engineer and of the Engineer-in-Chief must be most active from the first in supervising all these arrangements, of which the principles should be ordered by the Engineer-in-Chief.

It is probable that a large water supply system will be required at the base for supplying camps, establishments, shops, factories and quays; and similar systems will be required at the posts on L. of C. and at the advanced bases.

The Engineer-in-Chief will have decided on the means necessary for dealing with the water supply in the next phase, namely, a tract of waterless desert, involving many marches.

The army requirements, together with those of the railway, without which an army of this size cannot move at all, would not be less than 500,000 g.p.d. It is quite out of the question to carry such a large amount by rail. It is certain that the problem would be solved by the provision of a pipe line with suitable gathering grounds, at the base, from the shallow wells or from a river, if such exists. If a river is used a large filtering plant will probably be necessary. If a pipe line cannot be constructed owing to insurmountable engineer difficulties it would probably not be possible to move such a large force across the desert at all.

If the Engineer intelligence given to the Engineer-in-Chief is at all efficient he will be able to decide what head it will be necessary to pump against and what plant at the base, relay stations and pipe line will be required. Unless this is decided before the assembly of the Army, and plant is got together in good time, much time will be lost. If the Engineer-in-Chief is in the dark on all these points

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he will have to estimate on a very generous scale and at a very high cost.

The pipes and plant for relay stations, etc., must be carried by rail. The pipe line therefore must closely follow the route of the railway. The railway programme must include provision of trains for carrying and laying the pipe line. The speed of laying such a pipe line will thus depend on the speed of laying the railway. The details of laying a pipe line may be studied in the notes on water supply with the Egyptian Expeditionary Force. In this case 100 miles of pipe (more or less) was laid in 100 days, or thereabouts.

It must be borne in mind that the laying of such a pipe line with speed requires the exercise of the highest organizing ability and an establishment including specially suitable officers and other ranks together with a competent labour force is necessary. Such a work should invariably be retained in the hands of the Engineer-in-Chief or the Director of Works, and no formation or area commands should be allowed to interfere on any pretext whatever. The sites of the relay stations (if any) and of the various water areas on the route of the pipe line will depend on the tactical situation.

As the pipe line nears its objective it may be found that the enemy is holding the first wells in the third tract of country, namely, one of deep wells. In such a case the army would continue to be watered from the pipe line, which would be "T'd" off as required so that branch pipes would run along the rear of the line taken up. If this state of affairs was foreseen from the first it would have been necessary to calculate for far more than the 500,000 g.p.d. mentioned above.

As previously stated men and animals must be freely supplied with water and it is probable that in such a case the total amount pumped should be nearer 1,000,000 g.p.d. than 500,000 g.p.d.

The army thus gets into contact with the enemy on the fringes of the desert, and as the enemy is holding the first wells the army continues to be supplied from the pipe line. Water areas will be established in suitable positions and front line troops will be supplied from water areas sited as far to the front as possible.

During this stabilized period the General Staffs will be preparing schemes for attack and the Corps Commander will be able to give the Chief Engineer, long before receipt of definite operation orders, indications which will enable the latter to decide on the provision of such water areas as may be expected to be essential for concentration prior to attack.

As time advances it may be found that these will have to be altered, and the Chief Engineer must always be prepared for this, although, on the other hand, he can never afford to neglect to carry out such provision as indications appear to warrant. It is essential

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that sufficient facilities shall be provided and it is far better to provide too many than too few.

Indications as to future operations must, of course, always be jealously guarded as very secret, and the camouflaging of the reasons for the establishment of extra water areas is always a difficulty. Probably therefore, from this point of view, the establishment of more water areas than apparently are necessary confuses the inquisitive and to some extent solves this difficulty. Generally speaking, however, some risk must be accepted in establishing water areas on indications. As the country in rear of the enemy is known to be one of deep wells and therefore of, more or less, uncertain supply, it may be necessary to still rely on the pipe line supply for the first day of fighting. Hence plans should be prepared, if such a course is necessary, and material collected for extending during the first day's fighting, the pipe line as far as is reasonably possible, to water areas beyond the present front line.

The equipment and personnel of the Divisional and Corps Engineers will have been revised to meet the new situation of the third phase, during which we will have arrived at the condition of supply of water to troops during operations.

During the actual fighting and until stabilized again, men must be prepared to subsist on the minimum allowance of one gallon per head per day.

The supply being from deep wells pumps L. and F., unless stagings exist for relay pumping and in practice they never exist, are almost useless except for distribution purposes. The essence of water supply to troops during operations is speed. One of the most pitiful sights during operations is that of a crowd of thirsty men trying to fill a bunch of water bottles tied to the end of a string, from a deep well. Cavalry have been known to travel for 72 hours without water, chiefly owing to the means which have been supplied for raising it being inefficient.

It is useless for disciplinary purists to murmur platitudes in which the words "water discipline" are frequently repeated unless the means of supply which are provided are efficient.

It should be made possible to obtain water from any reasonable source down to 150 ft. depth within 20 minutes of arrival, and the duty of raising the water should be carried out by mechanical power or by horse power specially provided for the purpose. While operating the soldier should be fighting, marching, and digging, and should not be, as far as can be avoided, exhausted by pumping water. The mechanical lifting devices hitherto adopted for such situations are not yet satisfactory. The chain Helice pump capable of 1,000 g.p.h. at from 100 ft. to 150 ft. is the most suitable yet devised. It is suggested that experiments should be made with high lift,

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electrically driven, under water centrifugal pumps. It is believed that such outfits for supplying a Division could be devised for transport on a few lorries or their equivalent in horsed transport. Such outfits would get water with the speed necessary for operations and would be suitable for all varieties of water, whether open or deep well.

Failing this, the only known method of quick and efficient supply from deep wells is by means of a 20-25 gallon water bag. This bag is made in canvas or leather with a wooden bottom in which a valve is inserted. Such a bag is capable of lifting the best part of 1,000 g.p.h. from a well 100 ft. deep, and can be operated by a horse which should be supplied for the purpose. The valve enables the bag to be filled quickly even in shallow water.

The bags with their gear, consisting of blocks, tackle and scantlings for fixing, and the horses for operating them, should be added to the establishment of a Field Company, at the rate of six or eight per Company, for operations in a deep well country, until such a time as efficient mechanical devices are provided. If properly equipped in a manner suitable for the country the Field Companies of a Division can cope with the watering of their Division fairly well. One point, however, should be noted. The Divisional train as a rule moves independently to a great extent and frequently has to water at a distance from the Divisional Engineers. The train therefore should carry sufficient non-mechanical water gear to enable it to water itself when necessary.

As regards cavalry operating in anything like open country, the majority of the units very soon get completely out of touch of the Field Squadron of the Division, with the result that those so separated have to shift for themselves. It is considered, therefore, that each squadron should bear on its establishment one water bag set carried on a special pack horse. A cavalry unit could then water itself and avoid the scenes such as have been known to occur when thousands of cavalry with their tongues hanging out, have turned up at an infantry water area and demanded water from the already exhausted Divisional Engineers.

Prior to an army moving forward from a stabilized line, and especially when in contact with the enemy, the L. of C. Engineers should be prepared to follow up the formations, unrolling themselves from the head of the L. of C., and take over as quickly as possible such water stations as are relinquished by the formations in the course of their advance. It is desirable that the L. of C. shall carry with them water plants of the same nature, standardized as far as possible, as those carried by the formations, and effect an exchange in each case, an unerected set for an erected set, whenever such a course is necessary and practicable. This system is also desirable as between

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Divisional Engineers and Corps Engineers. Much time and labour is saved by such a system, but the institution of the system should be regulated by orders which should include dire punishment for him who palms off a " dud " set.

Obviously the closer the L. of C. Engineer units can get to the formation Engineers the better. The Engineers of L. of C. should arrange for pushing supplies of water gear as far ahead as possible. It is frequently the case that the *liaison* between the L. of C. and the formations is indifferent or that the L. of C., being a somewhat ponderous institution, is slow in extending its administrative system forward, following advances of the formations, and it may be found necessary to arrange that the Engineers shall carry out their forward moves, more or less independently of the remainder of the L. of C.

It may be desirable that detachments of the L. of C. Engineers shall actually, at first, accompany the Corps Engineer units in order to avoid more changes of personnel in manning power plants than are actually necessary and for other reasons. It is obvious, however, that this can only be done in the earlier stages of the advance.

We have now, thus, brought our army, from a water point of view, up to the point where they are about to go over the top. The men and horses are at the top of their form. The Divisional and other Engineers are on an establishment suitable for the next phase, and this includes a much larger proportion of engine drivers and fitters than has hitherto been allowed. The water stores of the Engineer units are suitable for quick supply from deep wells. Such units as are likely to get out of touch with the Engineers are equipped so that they can supply themselves. The Corps Engineers are equipped with sufficient transport to enable them to carry forward power pumps and other gear for establishing water areas on what, eventually, will be the L. of C. and with transport to enable them to carry forward a quantity of water stores for replacing worn-out and lost gear of the Divisional Engineers. The L. of C. Engineers are standing by ready to unroll themselves and take over from the Corps Engineers, and have ready packed on transport a further quantity of water stores for the purpose of establishing a comparatively small field park further ahead, and are, generally speaking, ready to push the Corps Engineers forward rather than be called up by the latter. Salvage operations for the present line have been arranged.

The Chief Engineer of the Corps has instructed C.R.E.'s to send back water reports frequently in order that the Corps Commander may be advised as to the water capacity of any particular area. C.R.E.'s have given similar instructions to their Field Company Commanders.

Special transport will have been forthcoming for the carriage of the extra water stores and C.R.E.'s and Field Companies will be in

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possession of motor cars and motor cycles for quick forwarding of stores and for sending back reports.

I may add that this last paragraph is a vision of what should occur. In practice it is extremely difficult to get any transport at all, and motor cars and cycles for Divisional Engineers have never yet existed.

We may now assume that the fight has commenced and that we are pushing back the enemy.

A Field Company will have been detailed to each Brigade or Brigade group. The C.R.E. must give the Field Company Commander a free hand to serve the Brigade. The situation is far too uncertain and changes are far too frequent to enable the C.R.E. at Divisional headquarters to keep close control. The success of the water supply rests therefore on the Field Company Commander. He must be in the closest touch with the Brigadier and watch the situation with the closest interest in order to obtain the Brigadier's views as to when and where to establish a water area. He must remember that when once committed in establishing a water area much time is lost if a change is essential. He must, however, often chance his arm and must be prepared to take risks. In the meantime, his officers and men are scouring the country as far as they are able to and ascertaining the water resources and sending back reports which eventually reach the Chief Engineer. Such reports can be only vague at first, but, where water sources are used, some idea of their capacities can be formed and thus reports can be amplified as time goes on. If the actual capacity in gallons per hour cannot be given, a report as to the troops actually watered at a given area is of great value. As regards the method of sending back such reports, Signals are generally overloaded with General Staff messages which take precedence, and the best method is by motor cycle orderly.

The mechanical Engineers with the Field Companies as well as the Field Engineers of the Chief Engineer are active, during the course of operations, in ascertaining particulars as to pumping plants, both enemy, military and native, which may be met with, with a view to their use.

The enemy military plants are, as a rule, not to be relied upon, as they are, as a rule, put out of action before being abandoned. Land mines should be suspected in their neighbourhood, and electrically-fired land mines may easily be connected to the magneto of the engine.

As regards native plants, it is usual to find essential parts removed, especially the magnetos. The owner, if he can be found, usually responds to kindness combined with firmness and promise of water for his own use, and produces the missing parts. It may be found to be possible, if the intelligence received is sufficiently good, to carry a certain number of spares for native plants.

If a town of any size is encountered the municipal engineer should

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be at once sent for and he should be instructed firmly but kindly to produce the water supply plans and to show the various areas where troops can most easily water. He should be instructed to place his resources in shops, stores and personnel at the disposal of the army.

Local workshops should be examined by the Field Engineer of the Chief Engineer and reported on. If it is decided to take any of these over, the necessary staff would be brought forward for the purpose. They would become L. of C. organizations eventually, unless sited too far forward.

It is very essential that the health of the native inhabitants shall be maintained, in order that they shall not become a menace to the health of the army. The native water supply must therefore be maintained and it may be necessary to arrange for repairs to native plant being carried out in shops thus taken over by the army as payment of local rates for the services rendered.

As the fighting and pushing back of the enemy proceeds, it will be found that very great deterioration of the company water gear will occur and within a fortnight a considerable proportion of the pump L. and F. will have become lost or broken, troughs and tanks worn out. These must be replaced quickly from the stores carried forward by the Corps Engineers.

In an oriental country, in addition to mechanical water plant, all sorts and conditions of native appliances will be found. These are often of the greatest value and should be used. In a stabilized position it often pays to erect these where natives can be hired at a low rate of pay to work them.

Gradually the operations will cease, both sides will become exhausted, temporarily, and we may assume that we will have arrived once more at a state of stabilization, although here and there the line will alter, as one side or the other straightens itself out locally. When this state occurs the water situation as in the last stabilized line, will repeat itself, except that the sources of supply will be at scattered deep wells instead of from the pipe line.

The Divisional Engineers' water areas will be found established at certain deep wells and the C.R.E.'s will be examining all other sources in their Divisional areas.

A very great deal can be done in a deep well country towards increasing the yields of wells. Old wells often have a considerable depth of rubbish at the bottom which, if cleaned out, may increase the yield very considerably. The winding gear of a boring rig is of the greatest use in such an operation.

Questions will now arise as to pumping forward towards the front line for the establishment of water areas for front line troops and for concentration as previously described. In selecting a well or other

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source of supply for this purpose, two conditions are essential, namely the capacity of the source must be sufficient and the site of the source must be reasonably far back and concealed in order that the pumping plant shall be as secure from observation and capture as is reasonably possible.

It is probable that a number of sources are safer and better than one large source for that purpose, unless the latter is very far back.

All engines and other machinery now sent up to fulfil demands at the front must have been thoroughly tested at the base shops before being issued and those responsible at the base must realize that this cannot be done at the front. A fault in an engine discovered when erected in the field may, quite conceivably, entirely upset a military operation which depends on the supply of water from that particular engine. All engines should be duplicated.

Arrangements must be now made for repairing the front line water plant in the shops established at an advanced base, or in the native shops taken over, unless the excellence of the railway traffic warrants the repairs being still carried out at the base.

The preparations for the next operations now become a repetition, with local variations, of those in the last stabilized position.

We have arrived at the time when further review should be made of the establishments and equipment of the Engineer units for the next operations. We have in front of us a certain stretch of deep well country and beyond that a country of open water. It follows that we must be prepared, as at present, for deep wells for a certain distance, and beyond that we need only carry the equipment required for open water. If the centrifugal pump outfits were available they would be carried right through the campaign as being suitable for all varieties of water. The water bags may be useful for open water. In open water country very much greater control of sanitary arrangements is clearly essential in order that the water shall not become contaminated. The red, white, and blue flags so dear to regulations may once more be brought into use, but even in open water country the typical water areas must be established and control must be maintained. It is not possible to water thousands of men and horses by the methods suggested in the text books. When an open water country is reached it is then especially necessary to investigate from local information what conditions may be expected in the driest season of the year.

Springs and rivers have a habit of drying up in the summer and they should be gauged from the first, when the stay is likely to be prolonged, in order that some forecast of the situation in the driest season may be made. In a country of springs it is often possible to make use of gravity in bringing the water to the water areas. An

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expenditure on pipe line is, therefore, very often the cheapest method in the long run, especially as it is better to use water from the source.

It is very rarely possible for an army to supply itself with water from wells dug for the purpose. The one condition in which this is possible is when the army is moving in a manner sufficiently leisurely for the purpose. In practice it can only be done where water exists at not more than 6 ft. depth in sandy soil which can be dug easily, and then only when not interfered with by the enemy and when a force can be sent forward to protect the works. The Norton tube, in such cases, is invaluable for testing depths, but as a means of supply it is practically useless.

Where a number of shallow wells are dug or a number of 3 in. tube wells are sunk and yield from each is only moderate, several can be coupled up to a land pump set by means of an arrangement of hose fitted with T's. Tube wells of this nature work very well in coarse sand, but are disappointing in fine sand.

A water boring organization is often of the greatest use in stabilized lines or on L. of C. This work requires highly specialized officers and trades and cannot be carried out by amateurs. Officers for this work are most difficult to find, but it may be noted that the governments of the Union of South Africa and probably also that of Australia, maintain boring sections as part of their irrigation departments. These sections are in every way efficient and suitable for service with an army.

Boring can only be made use of in the field where the source of supply is reasonably close to the surface, say within 200 ft., and the conditions are suitable for quick work. A boring section is most useful for the repair or renewal of native boreholes, if such exist. Such an organization should be attached to an Engineer Company at the head of the L. of C. unless it is, itself, a company. It should have the use of the repair shops, where a special expert in this class of machinery should be stationed.

The method of demanding engines, power pumps and pipe lines from the base requires co-ordination and control by the Engineer-in-Chief. Stock at the base is always limited. The demand, therefore, should give all such information, that is to say, quantity, static head and distance, as will enable the base to decide what plant of that available should be sent forward to fulfil the requirements.

Several chief reasons have prompted me to write this paper. One of these is that an opinion clearly exists that troops must not be spoon-fed and must be taught to shift for themselves. This is all very well, and I quite agree in principle, but the practice cannot be extended to water supply, except perhaps in the case of very small detachments. If troops are left to shift for themselves as regards water supply, then their efficiency will suffer.

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It is clearly our business to improve efficiency and we can only do this in the case of water supply by improving our system and equipment.

My second reason is to insist that mechanical means of raising water must as far as possible supplant man-power. A commander wants his men to be physically perfect when he starts operations, and wants them throughout operations to put every ounce of energy into marching, fighting, and digging, and none into domestic services such as water supply.

The mechanical means must therefore be mounted on first line transport, and must be available for use during operations.

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USE OF ELECTRICAL POWER ON THE WESTERN FRONT.

A lecture delivered at the S.M.E., Chatham, on 7th Oct., 1920, *by* MAJOR T. RICH, O.B.E., T.D., R.E. (T.).

INTRODUCTORY.

IT is a difficult matter, in the short time available, either to give many details of the work done by the belligerents on the Western Front, or to draw lessons from the work done and experience gained. The present lecture will therefore take the form of somewhat disconnected notes, concluding with some lantern slides dealing with French and German work.

In Germany the applications of electricity have been divided into two groups, "Starkstrom"—strong currents, meaning those used for lighting, power and heating; and "Schwachstrom"—weak currents, as used for signals, fire control, detecting and other apparatus. As the term "strong currents" is convenient, it will be used on several occasions during the lecture.

Strong current electricity began to be of value in military work soon after the pioneer developments of Siemens, Gramme, Hopkinson and Edison, the invention of the filament lamp being an important step in this direction. The first applications were in connection with coast defences and the lighting of barracks and depôts. The potential value of electricity in land warfare was recognized by the Council of the Institution of Electrical Engineers during the Fashoda crisis, and the Corps of London Electrical Engineers was then founded, with the idea of making a reserve of mechanical and electrical men who would be useful, not merely for coast defence, but also in the field.

During the South African war, besides doing searchlight work, a number of men of this Corps were engaged in the lighting of hospitals and railway stations, in addition to the protection of the piers of important railway bridges.

EARLY DAYS OF THE WAR AND SUBSEQUENT DEVELOPMENTS.

When the Great War broke out, however, the powers engaged had not properly realized the extent to which electricity could be used and all were to a material extent unprepared. The matter was taken in hand very rapidly by Germany, and arrangements were made for a strong body of electricians and auxiliaries to be attached to each army for electrical and allied work. This policy was followed by Austria in the Serbian campaign and in 1915 by the French. Each

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of these three powers realized that, for efficient working, it was necessary, with very few exceptions, to place electric lighting and power in the hands of a definite and responsible organization.

With regard to the British Army, the lessons of the South African war were apparently forgotten; the different services to a large extent made their own arrangements, there was very little co-ordination and it was not until 1918 that the necessity for some form of unity was recognized, and even then such centralization as existed was largely of a permissive character.

Although before the war a certain number of R.E. officers had been specially trained in the use of strong currents, very few of those so trained were, at the beginning of the war, put in positions where their experience could be utilized to the best advantage, this being largely due to the general shortage of trained officers.

A great deal of creditable electrical work was done in France by all branches of the service in the face of great difficulties, and it is to be hoped that the lessons bought at the expense of time, man power and money, will not be forgotten in the future.

Immediately the Americans joined the Allies, special electrical troops were got together, and, although in many ways the organization was defective, it was not apparently due to any lack of appreciation of the possibilities of electrical work on the part of those in control in the States or in France. The Americans, however, were able to take advantage of the experience of the Allies.

When comparing the use made of centralized power by the British Army in comparison with other powers it must be remembered that electrical distribution in the United Kingdom had been subjected to numerous obstacles in the past and it has received unsympathetic treatment, at the hands of the various authorities concerned, to such an extent that the rural distribution of power which exists in so many foreign countries is almost non-existent at home. The low price of coal made the problem more difficult. High-tension currents in this country were looked upon as a danger to the community, and proposals for the erection of overhead lines, whether for high-tension or low-tension work, were usually strenuously opposed. An indication of this conservative spirit is to be found in the fact that pressures of over 3,000 volts are still called "*extra* high-tension," a term likely to be applied in other countries to something over 70,000 volts.

In the New World and on the Continent, owing to the sympathetic treatment received, the overhead power line is a common feature of the landscape, the lines being usually run alongside the roads. In France about 4,000 Communes, in Germany about 16,000 Communes and in America probably well over 20,000 Communities are supplied with electricity, mostly through overhead lines. It was natural therefore for the French, Germans, Americans and Austrians to make

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use of local power supplies and to recognize the value of an organization for the whole army to deal with such questions. On the contrary, with us, it was often very difficult to get officers to recognize the value of uniformity in methods and co-ordinated supply. The war has proved the old saying that " where there is a will there is a way " and arrangements were often termed impracticable which were actually being used by the French and Germans. It must not be forgotten, however, that in France we were not in our own, or in any enemy's country, and that fear to give offence often tended towards timidity.

Applications of Electricity in the Field for Lighting and Power.

Now in modern war the nerve-wracking strains resulting from the use of high explosives, gas, and aircraft form a very important factor and necessitate the provision, where possible, of a degree of comfort for the troops, especially when resting, of a character quite unheard of in past wars. Good and convenient lighting in billets and dug-outs goes a very long way towards comfort, and good lighting is also an important factor towards the improved sanitation, which has so greatly reduced the death-rate from disease.

Up to date no form of lighting is able to compete with electricity for general convenience and safety. For the lighting of depôts, barracks, hutments, schools of instruction, hospitals, casualty clearing stations, the headquarters of formations, and dug-outs, electricity was supplied in France from portable or semi-fixed plant or from civil or military power supply systems. Electricity has the great advantage that, during air raids, lights can be controlled at a moment's notice. Despite the customary remark that this or that fire has been caused by the " fusing of an electric wire," surprisingly few fires are actually caused in civil and military life by electricity. Oil lamps are dangerous and are a nuisance ; it is very difficult to find men capable or willing to keep them in order, and very large quantities of paraffin are used for lighting fires. Acetylene is sometimes useful, but for work in dug-outs it has the disadvantage of being very susceptible to shock, and may be put out by a neighbouring explosion.

Strong currents are useful for motors for pumping for water supply, chaff cutting and grinding, general machine tool and workshop driving, concrete mixing, bakery machinery, laundry machinery, wood chopping and, in mines, for ventilating and pumping. It is interesting to note that both the French and Germans often used power from power lines for driving forest saw-mills in preference to steam-engines, even where water supply was not a matter of great difficulty, the refuse wood being used as fuel for the troops and the sawdust as bedding for horses. In hospitals, owing to the powerful apparatus used, as much as 10 kw. has been used for one X-ray tube, and strong currents are especially useful for combined light and

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heat baths, which can be improvised with old carbon filament lamps; these baths are very useful for wounded men who are suffering from exposure.

Owing to the complicated nature of the appliances used in warfare the different workshops, for repairs and for experimental work and for the temporary manufacture of special expedients, have become important establishments, requiring a considerable amount of power.

With regard to the general question of motive power, petrol and oil engines with direct drives are the competitors of the electric motor. The extra labour for supervision and repairs, the extra lubricating oil, the fire risk, the low efficiency usually resulting from the low engine load factor, and the difficulty regarding fuel supply make the individual internal combustion engine a less formidable competitor, however, than would appear at first sight. Electric generators and motors have proved to be reliable machines in war and, considering the amount of knocking about to which they have been subjected, the amount of repairs found necessary has proved to be small, especially as compared with petrol-engines.

Requirements of Different Zones.

The conditions which exist during different campaigns must of necessity differ greatly, but in most cases the area of operations can be divided into the following zones :—

(i).—Home bases, with which can be included emergency camps.
(ii).—Overseas bases, base camps, depôts and workshops.
(iii).—Line of Communication (generally termed L. of C.).
(iv).—Forward areas.

The requirements vary considerably in each of the above zones.

In the first three zones the lighting of hutments and depôts forms a material part of the work to be done, and in forward areas the lighting is largely confined to casualty clearing stations, mobile workshops, headquarters of formations and shelter tunnels; in the former zones current is supplied usually from local power stations or from semi-fixed plant, while, in the latter, portable generating plant is largely used. Motors are used in all zones.

Types of Current and Voltage.—British and Continental Practice.

Whenever strong currents are to be used in civil or military life, the question of the type of current and voltage to be used is a matter requiring great care; general practice at home has naturally an influence in the matter, especially regarding the rapid supply of suitable apparatus. In the United Kingdom in civil life direct current is mostly used for low-tension distribution on the three-wire system, with 200 or 220 volts between outer and neutral, and 400 or 440

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across the outers. Low-tension three-phase distribution is the exception, and practically all the high-tension and low-tension distribution is done with underground cables.

In France and in several other continental countries the older power stations were laid out for direct current and therefore in the central districts of such towns as Boulogne and Rouen direct current is supplied. In order to supply the suburbs and outer areas three-phase current is usually generated, being transmitted at high tension and distributed as three-phase through static transformers. In France, as in many other countries including America, the lamp voltages are usually from about 110 to 125 volts and, where three-phase current is used, the motors are usually arranged for 190 to 220 volts across the phases. Outside America, where alternating current or three-phase are to be found, 50 periods are the rule. It is naturally desirable so to adjust matters during warfare that the utmost use can be made of local facilities.

With perhaps the exception of Germany, all the powers began by using direct currents, but during the war the advantages of the three-phase system, except for perhaps the smallest installations, became so apparent that at the end of the war it was being used extensively, the French using it for quite small generating units such as 20 kw. In some sections of the British Army in France, there was a great prejudice against the use of three-phase current, and this was especially the case in the Transport Directorate.

Advantage of H.T. Lines, 3-phase Distribution and Co-ordination of Supply.

Once a site has been selected at the base or on the L. of C. for use as an important military centre, rapid expansion takes place, and camps, depôts, and workshops begin to be formed. Too much concentration is undesirable from the point of view of safety from aircraft, so that a number of points requiring light and power get scattered round important centres on the rail or road. The problem is the supply of light and power with the minimum of labour and delay. Originally each little point had its own, or at least wanted its own generating plant, so that the labour for maintenance and repair became a serious matter.

The practical limit of distribution of direct current from a temporary power station is limited to a few hundred yards, especially if the use of very heavy copper cables is to be avoided; whereas, once three-phase current is adopted, the limit runs into miles. A temporary high-tension power line can be run up almost as rapidly as a telephone line and for small branches galvanized iron wire can be used. The result of the use of this system is that, once three-phase plant is put down to supply a workshop or depôt, neighbouring camps

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and institutions can be rapidly supplied without further moving plant, with the aid of step-up and step-down transformers. For the practical development of such a system it is absolutely necessary that the generation and distribution of power should be in the hands of one organization ; otherwise there is a danger that " dog-in-the-manger " tactics will be adopted and one unit may refuse to run their plant to suit the requirements of another.

Three-phase current supplied from civil stations was largely used by us at such places as Calais, Boulogne, Dieppe, Havre and Rouen, and but for the set-back of March, 1918, it would have been used extensively in the area round St. Omer.

The French and Germans, and later, the Americans adopted the policy of linking up the main power stations with special trunk lines at 30,000 volts or more, the subsidiary stations being as far as practicable interlinked by lines at lower voltages ; from the resulting network three-phase current was supplied to a number of forward areas. The Germans probably put up over 2,000 miles of high-tension line on the Western front, the French over 1,000 miles, and, although the conditions were not so favourable in the British area, probably something like 80 miles were put up by us. One great difficulty we had was the lack of any definite detachments for the construction and maintenance of aerial lines.

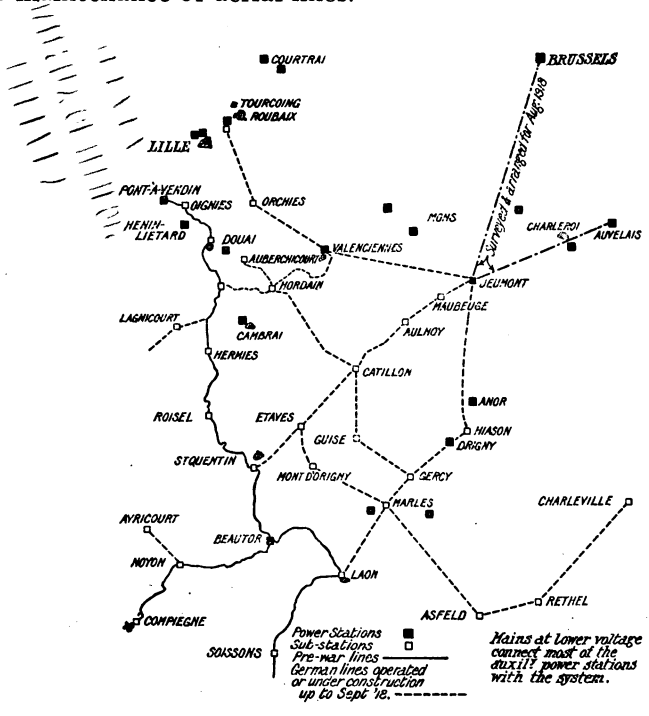

FIG. 1.—*German Power Lines at 45,000 volts in the Occupied Zone.*

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Portable Plant.

The great problem is the supply of strong currents for mobile and semi-mobile workshops, casualty clearing stations and other electricity-consuming points in forward areas. In France with us there was no material uniformity in system nor yet in channels of supply of apparatus and accessories. Each branch of the Service wanted to run its own show, so local co-ordination was a difficult matter. A large amount of portable generating plant will always be wanted in warfare, but its use should be cut down to a minimum. During the war the question of the conservation of fuel supply was a matter of the utmost importance, and at one time things were almost touch-and-go with the available supplies. Economy in liquid fuel is therefore a matter of great importance.

It is difficult to lay down the law regarding the best type of portable plant. Generators direct coupled to high-speed petrol sets are convenient for transport, but experience of the British, French, German and Austrian armies tends to show that they are difficult to keep in order with the inferior labour usually available, and are extravagant in petrol and lubricating oil. The medium and low-speed paraffin and petrol engines undoubtedly gave the best results, but they are difficult to transport. French and German makers of portable generating sets usually used channel iron bed-plates, but unfortunately nearly all the British makers insisted on the use of heavy cast iron bed-plates. On all direct coupled sets some form of flexible coupling between generator and engine is desirable, but as far as possible the couplings should be standardized to enable generators to be changed when required.

The excessive repairs and other difficulties with all classes of internal combustion engine, whether for electric or direct mechanical drive, would have been largely reduced if schools of instruction had been set up for the auxiliary labour liberated for such work. This was done to a certain extent by the Germans and Austrians. Any man-power taken up for such instruction would have been more than set off by the reduction in breakdowns and general repairs. An unofficial school for such work was started in one area on the L. of C. and, despite the short training period, the experiment proved successful. At the end of the war the French were beginning to adopt portable superheater steam-engines for some of their generating plant, and this arrangement should prove very useful for hospitals which require steam for baths, cooking and washing. The exhaust steam could also be used for other purposes.

The A.S.C. sent to France a number of M.T. repair shops, mounted on motor chassis and fitted with 3½ kw. high-speed direct-current, direct-coupled petrol sets. With these sets it was found that, if the generator was taken off the engine bed and bolted to the flywheel of the four-cylinder engine of the chassis, which engine had then

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merely to jog round, the repairs and petrol consumption were reduced to a minimum. The Ordnance for their larger mobile workshops had a number of steam tractors to haul their machine tools and gear; these tractors were also used to drive generators by means of belts. Practically all the portable sets used by the British were arranged with D.C. generators at 115 or 220 volts.

One branch of the Directorate of Transport ordered 25 three-phase 50 kw. direct-coupled sets with eight-cylinder petrol-engines mounted on channel beds. These were intended for use after an advance, to take the place of plant destroyed by the enemy, for connecting up to such part of the three-phase supply networks as remained. Owing to lack of *liaison* with those in France, ignorance of conditions in the war area and the absence of any centralized organization for the control of electric power matters, the bulk of these sets were constructed for a voltage range practically unknown from Antwerp to the Mediterranean. Owing to the lack of flexible couplings moreover, these so-called portable sets, some of which were supplied with wheels, could only be run satisfactorily on a bed of concrete.

The Germans had some three-phase steam-engine sets, mounted on railway trucks, of a capacity of 125 K.V.A. at 15,000 volts and one of these sets is now at Gosport. The Austrians had a 300 kw. set similarly mounted and the British Transport Directorate had several 200 kw. D.C. sets with steam turbines mounted on trucks. We had also two 1,000 kw combined D.C. and three-phase floating power stations. At the end of the war the French were beginning to use three-phase portable sets, so arranged that they could supply power to a hospital or workshop direct and supply other points in the neighbourhood through transformers. When conditions allowed, the generating plant would be replaced by a power line from the rear, and the portable plant kept in reserve or sent elsewhere.

It should be noted that both the French and Germans wired out a number of villages and small towns in order to supply billets with light, the French arranging with power companies to take over the work when done with.

CENTRALIZATION OF SUPPLY.—STANDARDIZATION OF APPARATUS.

If electrical light and power and, for that matter, general mechanical power is to be made use of efficiently in the future, it would seem to be necessary to hand over the general control of such work at home and in the field to the Engineers, on somewhat similar lines to the work done by Signals. All general lighting and power work should be carried out by Engineer men or men responsible for their technical work to the Engineer officers. In the field a number of auxiliaries are always necessary, and the French found that it was desirable for the local unit to choose the men and hand them over for training and

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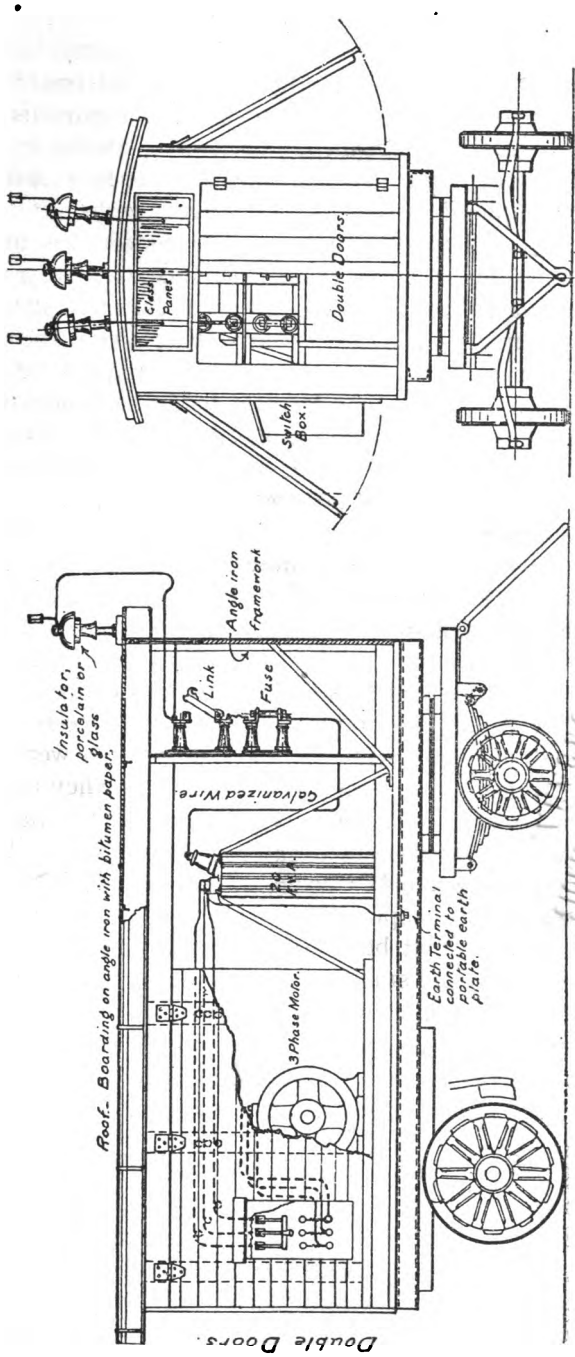

FIG. 2.—*Portable Transformer Cabin*; 15,000 *to* 120/200 *volts*, 120 *K.V.A.*

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technical supervision to N.C.O.s and men of the electrical corps; with such an arrangement local units are not likely to detail "rotters" to take charge of work affecting their own comfort.

To avoid competitive buying and claims for departmental priority, and to reduce the number of types in use, all apparatus should be purchased by the Royal Engineers, or, where special motor-driven machinery is required by a specialist corps, the motors and special generating plant should conform to R.E. standards.

With regard to the question of the supply of stores it is unnecessary to purchase the very best class of electrical accessories for temporary work at home or in the field. The life of a hutment installation is short and in the many cases where cleat wiring is used the question of the mechanical protection of conductors is the main point. For war work commercial pattern apparatus which can be turned out rapidly has proved to be the most convenient. Again, it is useless to use high-grade wire if it is to be installed by comparatively low-grade wiremen. Except where batteries are concerned moving iron instruments are preferable, they are stronger than moving coil instruments and can be used for D.C. or 50-period alternating current. At one time in France many electric generators and motors were ordered almost as they were wanted and to avoid this and to facilitate supply the mechanical officer attached to the staff of the Engineer-in-Chief ordered petrol electric sets and other machines in batches. Owing to the delay in the supply of accessories from England through the official channels large quantities of accessories were ordered in Paris and these proved on the whole to be satisfactory and economical. When the question of using three-phase apparatus in more forward areas arose, a series of motors were ordered in England and standardized, different sizes being ordered from different makers. To assist other Services these were supplied as far as stocks allowed, a voluntary standard system being thus introduced. These motors were designed so as to be usable in connection with public supply in most parts of France. A certain number of transformers were ordered with multiple windings so that by different connections they could be used for 5,000 or 15,000 volts and some were ordered suitable for 3,000, 5,000, 6,000 and 10,000 volts.

ORGANIZATION OF E. AND M. WORK.

It is interesting to note that, acting independently, the Germans, Austrians, French and British evolved the electrical and mechanical unit, which, to a greater or lesser extent, handled electric light and power, air compressors for drilling (with the exception of the last), water supply and petrol-engines for direct driving. The Germans had an Electrical battalion for each army, the French a large company, the British a company; but the British E. and M. Cos. had not the same control as those of the French and Germans. It is desirable

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to continue and develop this system. Furthermore it is an advantage either that the O.C. E. and M. Company should be *ex officio* staff officer to the Chief Engineer for such work, or, as in the 2nd Army at the end of the war, that a staff officer should be detailed to keep the *liaison* between the staff and the O.C. unit. It is most important that electric light and power on the L. of C. should be under the same general technical control as that in army areas.

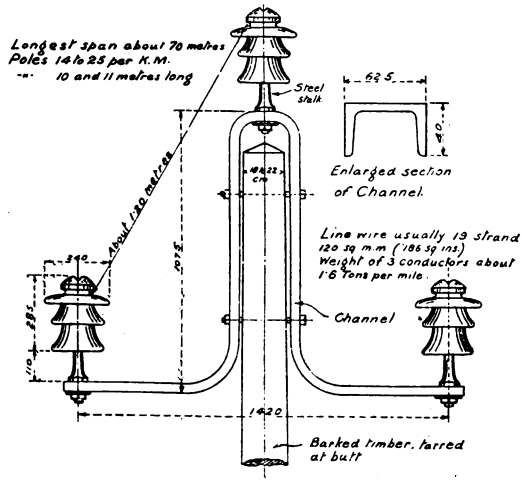
Longest span about 70 metres
Poles 14 to 25 per K.M.
10 and 11 metres long
Steel stalk
Enlarged section of Channel
Line wire usually 19 strand 120 sq m.m (186 sq ins.) Weight of 3 conductors about 1·6 Tons per mile
Channel
Barked timber, tarred at butt

FIG. 3.—*Standard Cross-arm for* 45,000-*volt Power Line.*

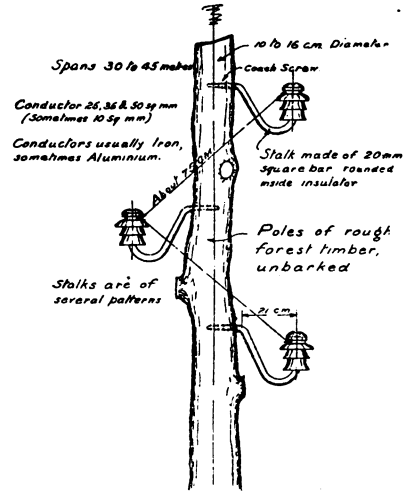
10 to 16 cm. Diameter
Coach Screw
Spans 30 to 45 metres
Conductor 25, 35 & 50 sq mm (Sometimes 10 Sq mm)
Conductors usually Iron, sometimes Aluminium.
Stalk made of 20mm square bar rounded inside insulator
Poles of rough forest timber, unbarked
Stalks are of several patterns

FIG. 4.—*Branch Line Construction, up to* 15,000 *volts.*

In the German army the " Starkstrom " troops were on a basis of territory, so that changes in army or L. of C. areas did not lead to great alterations in work. Owing to the fact that power lines may

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have to pass through several commands, a strong central control is desirable, and it is to be noted that during the war the French had periodical conferences of electrical officers.

The E. and M. companies should be divided into sections for erection of plant, maintenance work, workshop work, water supply when included, and a power line construction section is usually necessary. During manœuvres men should be trained in the rapid construction of power lines.

It would be desirable for a Territorial Force of Electrical and Machinery men to be formed, so that, either by expanding peace time skeleton formations or creation of new units, the requirements of a modern army could be met.

The work of an E. and M. Company is of such a varied character, that for efficient working it is practically impossible to lay down a rigid mobilization table ; and during the war it was difficult to get the authorities to understand this. The French and German organizations were much more elastic than ours in this respect. The work of such companies on the L. of C. is of such importance that it should not be reserved for men of the lowest medical categories only ; men for handling high-tension lines and climbing poles must be active and have their wits about them.

It would be desirable for the Intelligence Branch of the War Office to keep in touch with electrical developments in all likely seats of war, collecting notes, maps and statistics regarding power stations, power lines and voltages. A large amount of useful information could be gathered from the British and Foreign Electrical and Engineering Press.

When starting a campaign in a country where electric power schemes are in operation, it is desirable to have all possible information collected as, even if the main power stations have been destroyed, quantities of useful material would in most cases be available

A number of lantern slides were then shown, many of them depicting German practice. The author has often been told that, as we won the war, adverse criticism of some of our own work, and praise of some of the German work are stupid and futile. A man in a boxing match who sticks out sixteen rounds before getting a knock-out blow, and nearly knocks his opponent out several times during the fight, must show in his methods points worthy of commendation and imitation, and must be a better man than one who goes down during the first round. There are many features of German military electrical work worthy of study.

Further particulars of work done by the German Army can be found in a pamphlet by the author, *Notes on Electric Light and Power Work of the German Army*, published by H.M. Stationary Office, price 1s. 6d.

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USE OF ELECTRICAL POWER ON THE WESTERN FRONT

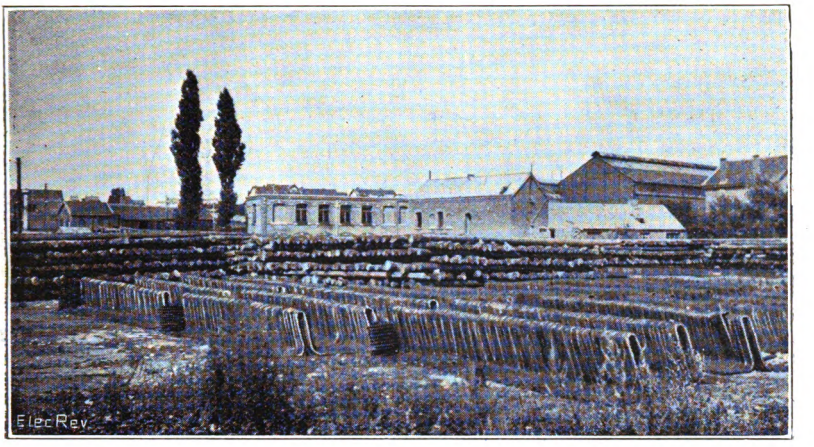

FIG. 5.—Stock of Poles and Cross-arms at Jeumont for German Military. 45,000-volt Line.

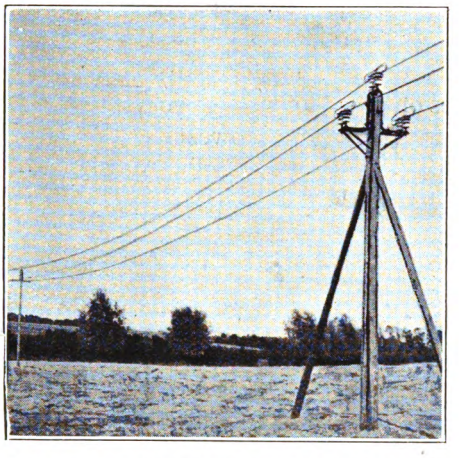

FIG. 6.—German 45,000-volt Line and Anchor Pole; Stranded Aluminium Line 120 sq. mm.

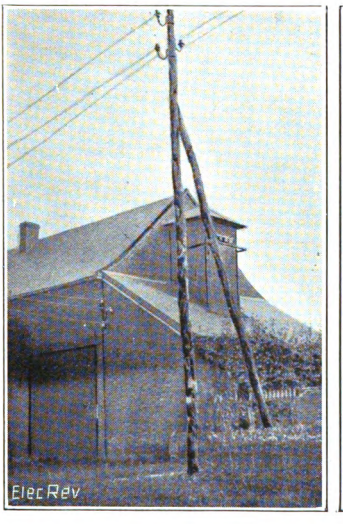

FIG 7.—Sub-station Attached to Farmhouse.

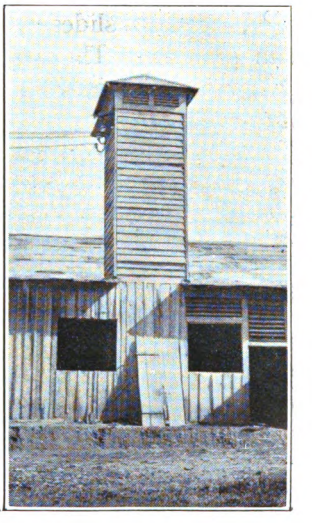

FIG. 8.—Sub-station at a Sawmill.

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TWO NEW METHODS OF CONCRETE CONSTRUCTION.

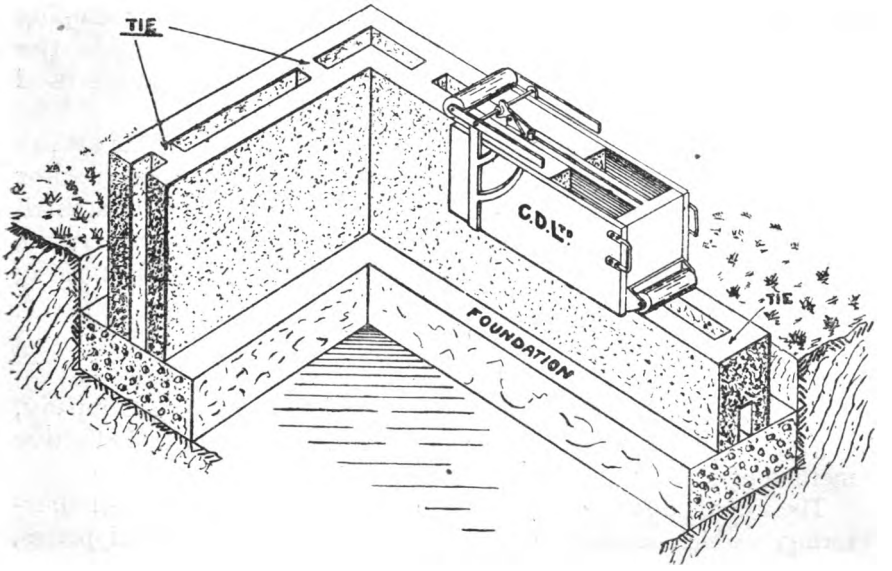
By MAJOR G. C. V. FENTON, D.S.O., R.E.

THE "C.D.L." SYSTEM OF CONCRETE CONSTRUCTION.

THIS system of construction, which is the property of the Concrete Dwellings (Parent Company), Ltd., of 1, Carteret Street, Westminster, London, S.W. 1, was exhibited at the recent Building Trades Exhibition at Olympia, and should prove of interest and value to officers employed on the construction of barracks and other buildings.

The system offers the great advantage of the construction of the walls of buildings of concrete, *in situ*, without the use of wooden or other form of shuttering, and by means of a machine which requires no skilled labour to operate. Its use in the United Kingdom should give considerable economy over other forms of concrete wall construction and in Indian and Colonial stations, where labour of a skilled nature is scarce, it should prove exceptionally advantageous. The company claims that unskilled labour can obtain proficiency in the use of their machine in two weeks.

The ordinary concrete block machine generally entails the precasting of blocks, and their storage to permit setting before incorporation in the building. They then have to be built up in mortar, plumb and level. The "C.D.L." system eliminates all handling of the concrete once it has been placed in the machine and provides a monolithic structure.



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The machine is shown on the diagram in actual use on the construction of hollow walls. It consists of four cheeks or sides, hinged on to an end plate, which, by the operation of simple clamps, can be fixed parallel with each other. The release of these clamps permits the cheeks to fall into wedge-shaped positions in relation to the base. In the former position, the filling of the machine takes place and the concrete can be tamped without any fear of distortion. After filling, the clamps holding the cheeks can be released, permitting the cheeks to assume the wedge-shaped position and thus be out of contact with the new green concrete, and the machine can be moved away without disturbing it. Rollers are provided to facilitate easy motion.

The method of working is that the machine is placed in position on the previously laid foundations or plinth, clamped in the filling position and filled with concrete, which is well tamped. It is then unclamped, pulled forward for the whole of its length, reclamped in the filling position, and again filled. The process is repeated until the whole course round the building is completed. The following day, the machine is placed on the top of the course made the day before, which has by that time partially set, and the next course completed. By short intervals between the courses, a homogeneous monolithic structure is obtained.

Machines can be made to construct any thickness of wall, but the standard machine generally supplied for use in the United Kingdom builds a 9 in. hollow wall, consisting of $3\frac{1}{4}$ in. inner and outer shells, separated by a $2\frac{1}{2}$ in. cavity. Regarding the courses, it has been found that 15 ins. high gives the best results. This standard machine also forms the ties in concrete, but each tie only goes half the depth of a course, and breaks joint with the others, thus securing a continuous air space within the walls of the building and thereby precluding damp or condensation. If however considered desirable the machine can be made without the concrete ties and metal ties used instead.

The main drawback to this method of construction, as far at any rate as the Colonies are concerned, is that the machines are not for sale. The company hires them out at a Royalty, based on a small percentage of the total cost of the building. In India however the machines are manufactured and sold by the Empire Engineering Company of Cawnpore.

CLIMBING STEEL SHUTTERING FOR CONCRETE WALLS.

AT the same Exhibition, the Climbing Steel Shuttering Company, of 515, Queen's Road, Sheffield, exhibited a very simple and effective method of construction of concrete walls.

Their method is merely by what they term "Climbing Steel Shuttering," which consists of light bolstered galvanized steel plates,

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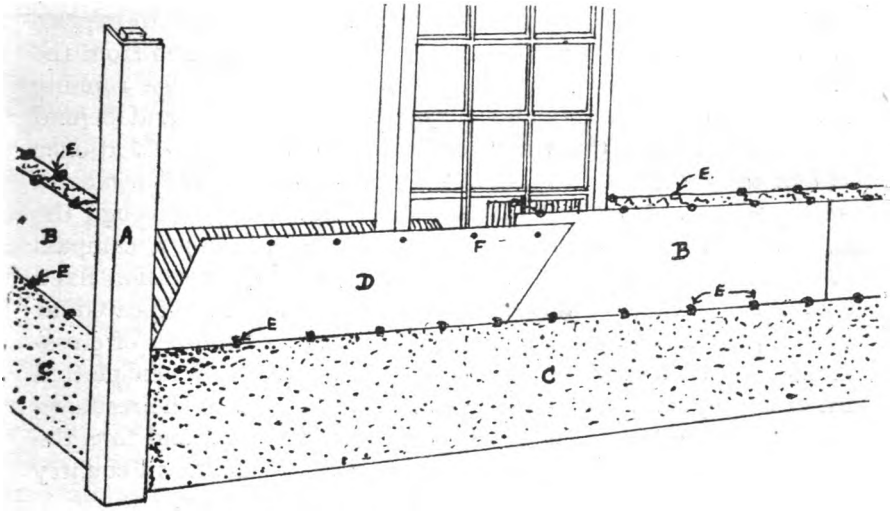
with a number of holes pierced in the upper and lower edges of the shutters. The shutters are held apart the thickness of the wall to be constructed by means of wires which are passed through these holes. No uprights or guides are required except at the extreme corners of the building, where ordinary corner casing of wood is erected and fixed plumb. From these corners a line is required to keep the work straight and true.

As soon as the casing has been fixed in position, the concrete is filled in, and when it has set sufficiently stiff, the lower wires are cut on the outside and the plates are turned up from the bottom, the upper wires acting as hinges. The upper edges are then wired by means of the holes, the casing is aligned and is then ready for the fresh charge of concrete. In short, the plates revolve to the top of the wall. These plates are made in lengths 5 ft., 6 ft., 7 ft., 8 ft. and 9 ft., height 17 inches, thickness $\frac{5}{32}$ in., weight 4 lbs. per superficial foot. The size of the wires used is No. 15 or 16 gauge.

This system of construction can be used with either plain or reinforced concrete and a special point is the very light nature of the plates, which facilitates easy handling. The firm claims that a square yard of shuttering, both sides, is got ready, that is, wires cut, plates turned up and rewired, in less than five minutes.

The method of building by means of this form of construction is as shown in the following isometric sketch :—



References :—A. Corner casing of wood.
B. Patent shuttering fixed and filled with concrete.
C. Completed concrete wall.
D. Patent shuttering being folded up.
E. Wire fastenings.
F. Holes in shuttering for wire fastenings.

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SURVEYING ON THE SOMALI COAST.

THE following is an extract from an officer's narrative of the operations on the Somali Coast :—

The *Odin* was continually moving along the coast keeping up communication between Berbera and Las Khorai and assisting the Military Staff to map, in conjunction with other information, the unknown country in the vicinity of Jidali, by providing a base at sea from which to take bearings. A landing compass was also set up at Burnt Island for this purpose and valuable data were obtained by the military authorities from these two sources, enabling them to fix, with some degree of accuracy, the positions of several of the Mullah's forts. One method used was so unusual, and yet so successful, that it seems worthy of record. Certain natives with an intimate knowledge of the country were taken to sea in the ship, and these men seemed to have an uncanny sense of the direction in which lay any place with which they were acquainted, which one can only compare to the homing instinct of the carrier pigeon. On arrival off the desired spot they would be asked the direction in which, for example, Jidali lay. It is necessary here to explain that at a distance of, roughly, three to eight miles inland from the coast there is an enormous, almost flat, limestone ridge running parallel to the shore and about 7,000 feet in height, and behind which were situated Jidali and Medishi. The native would at once point in the direction and would then be told to "lay" a maxim gun on the exact spot; the Staff Officer then looked through the sights and noticed the place the sights were laid on; a compass bearing of this spot was then taken and the ship's position fixed as accurately as possible. This operation was then repeated at various positions along the coast, and thus a large number of cross-bearings were obtained of Jidali and other places. When plotted on a map they came out with extraordinary accuracy, the resulting "cocked hat," in most cases, being exceedingly small, and thus the position of many of the Mullah's strong places in unknown country were definitely fixed within a very small margin of error.

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PROFESSIONAL NOTES.

CONSIDERATIONS IN THE DEVELOPMENT OF PONTOON DESIGN.

(CONTRIBUTED BY THE R.E. BOARD.)

THE question as to the desirability of introducing a steel pontoon in place of the present wooden pattern having again been opened the design of a suitable form of steel boat (or boats) to fulfil the requirements of all classes of pontoon bridge in the future is now being reconsidered.

The investigations so entailed have necessitated a somewhat exhaustive examination into the numerous considerations affecting the design of pontoon bridges generally, and it is thought that the following notes on this subject may be of interest.

2. In considering any future design for a suitable form of pontoon it is no longer sufficient to base the requirements on one class of bridge only, namely, that formerly classified as "medium," which provided only for the passage of the fighting troops of the division and horsed transport up to a rear axle load of two tons. The pontoon of the future should be such that, whilst its characteristics of form and structure should allow of the rapid construction of a bridge to meet the foregoing requirements of a Division on the basis of a single pontoon for each pier, a simple combination of two or more such pontoons should be capable of providing piers of the buoyancy necessary for the heavier loads which have been imposed by the introduction of the various classes of mechanical transport.

3. During the late war a type of heavy bridge (now well known) was designed by Lieut.-Colonel Sankey, consisting of piers of three boats made up from nine sections of the existing pontoon equipment together with a heavier form of superstructure to take "heavy" loads up to the classification given in para. 4, subject to certain limitations imposed by the resulting reduction in waterway. This bridge having successfully fulfilled its purpose as an emergency measure has now been approved and sealed as a *Provisional* pattern, but only such quantities of this type as are required for instructional purposes are being maintained in peace. Certain improvements and alterations in regard to the arrangement of piers and other structural details having suggested themselves, however, as the

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outcome of the Sankey design, it was decided to investigate the possibilities of evolving improved forms of pier and superstructure to take medium and heavy loads (see para. 4). This work was accordingly taken in hand at the Experimental Bridging Establishment, Christchurch.

A new design worked out by Major Martel, which provides for the construction of a "medium" and "heavy" bridge (see *new* classification, para. 4) from the existing wooden pontoons is being developed, and the trials in connection with this design are approaching finality. Perhaps the most novel and interesting feature of this design is the complete decking in of the pontoons, which, by eliminating the chance of swamping, permits of a reduced freeboard with the resulting increase of buoyancy. This bridge was described in further detail in the *R.E. Journal* of November, 1920. Thus, although the introduction of a decked pontoon as the standard pattern of the future has not yet been *definitely* decided upon, the trials so far carried out have given good grounds for anticipating that its adoption will eventually be approved.

The investigations referred to in para. 1 which are now being carried out with a view to considering the desirability of introducing a steel pontoon in place of the present wooden type, have been reopened *primarily* with reference to the facility of output and economy in production which it is hoped may be thereby effected. But it should be made clear that the reconsideration of this question of steel *versus* wooden pontoons is not in any way to be regarded as dispensing with the need for developing designs or improvements based on existing equipment, such as the Martel design above referred to, the trials in connection with which are now proceeding and approaching finality.

4. The following statement gives the latest classification for pontoon bridges, and the loads to be carried by each class:—(See also *Plate* V).

(*a*). *Light Bridge.*
Heaviest load, ammunition wagon for 4·5 in. howitzer and limber drawn by six light draught horses (*Plate* V., *Fig.* 1). Maximum axle load, two tons.

(*b*). *Medium Bridge.*
Heaviest load, Foden lorries in a string (*Plate* V., *Fig.* 2). Maximum axle load, eight tons.

(*c*). *Heavy Bridge.*
Heaviest load, medium "D" tanks, equivalent to a maximum axle load of 16 tons. (*Plate* V., *Fig.* 4).

Note.—The maximum nett buoyancy required per *pier* (including weight of superstructure) for each of above classes is—(*a*) 4½ tons, (*b*) 14½ tons, (*c*) 21 tons.

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5. The main considerations governing the design of a pontoon (or pontoons) which shall most efficiently provide for the requirements of *all* classes of bridge, as defined in the foregoing paragraph, and their influence on the structural factors involved, will now be examined.

6. (*a*). The ideal to be aimed at, though it presents greater difficulties than might at first be imagined, is to produce one single form of pontoon which will provide for all the classes described under para. 4. The various reasons for this are too obvious to require explanation, but attention might be called to one of them, namely, the desirability of obviating the introduction of more than one class of wagon or trailer for the transport of all pontoons.

(*b*). The pontoon when grounded should be capable of supporting without permanent distortion the maximum dead load which it will be required to carry in bridge (5¼ tons). This is not intended to imply that the skin of the pontoon is not expected to be damaged or holed by grounding, but only that the bridge should not collapse, and is a very essential condition to bear in mind when deciding upon the form of the cross-section and the structural principle upon which the sides and the whole internal framework are to be designed.

Various forms of cross-section suggested are shown in *Plate* I. (See also (*d*) "Saddle *versus* gunwale loading").

Fig. 1 gives a displacement area of 11.60 sq. ft. for a freeboard of 8 in. If, however, the depth is increased we get more buoyancy for a smaller increase in weight than if the buoyancy be increased by an addition to the width.

In this case practically the same buoyancy can be obtained by reducing the width and increasing the depth as in *Fig.* 2.

Fig. 2 gives a displacement area of 11·47 sq. ft. for 8 in. freeboard. The boat is not quite so stable as *Fig.* 1, the shallower boat, as the meta-centre is lower; but this consideration is not of great importance in a pontoon, as the boats are held rigid in bridge, and cannot overturn. A reduction in width, of course, increases the waterway.

Figs. 1 and 2 can, of course, be modified so as to allow of saddle loading by the addition of bracing as in *Figs.* 3 and 4.

Fig. 3 shows a rectangular section adapted for saddle loading.

The square corners are a disadvantage both on account of the liability to damage by blows, and the added resistance to current.

This section gives a displacement area of 11·10 sq. ft. for 8 in. freeboard.

Fig. 4 is a similar section for saddle loading giving a displacement area of 11·07 sq. ft. for 8 in. freeboard, with rounded corners.

Fig. 5 is the same section as *Fig.* 2, but adapted for saddle loading, with a central girder.

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(*c*). Two pontoons when coupled together should be able to withstand total immersion without distortion, with the weight applied on a 10 ft. saddle in the centre of the pier so formed.

Whilst the nature of structure must be such as to afford the longitudinal stiffening necessary to resist buckling in the single pontoon itself, the most difficult problem of this aspect of the design has been to produce a suitable form of coupling which will provide the necessary strength for the connections in the heavier piers without introducing an undue addition of weight. This problem of coupling should be more easily solved in the case of a pontoon with a *central girder* than in the case of a pontoon in which the *sides* are treated to resist buckling. See also (*d*) below.

It should be noted that the Sankey design employed a very stiff and heavy saddle (12 in. by 12 in.) which obviated the necessity for additional strength in the couplings. An important reason for the strengthened coupling is to save weight by eliminating the heavy saddle. Experiments are being carried out in this connection.

Plate II., *Fig.* 1, gives the type of couplings now being constructed for decked-in wooden pontoons. The stress to be taken is eight tons working load, and these couplings have been tested to destruction at 20½ tons.

Fig. 2 shows a similar type with an annular ring and semi-circular tapered lugs. The breaking load is estimated at 25 tons. These types are for the bottom couplings of wooden pontoons. For steel pontoons, owing to the greater ease of fixing the coupling various forms of locking devices can be employed.

Fig. 3 shows such a device, which is somewhat similar to the present gunmetal couplings on wooden pontoons.

The stress on the connection to the boats can be easily distributed for the steel pontoons by means of fish-tailed plates, whereas, for wooden pontoons it is necessary to have a steel strap running the whole length of the pontoon.

For pontoons with central girder (*Plate* I., *Fig.* 5) a simple coupling of staples bolted to girder, and pin, is suggested.

(*d*). Closely allied with the foregoing considerations (*b*) and (*c*) in their influence on the principles of the design, is the question as to whether the load is to be taken on a central saddle or to bear directly on the gunwales in the manner adopted by certain foreign countries. These alternative methods should be regarded primarily from the point of view of the effect they will have on the following considerations:—(i.) Ease and rapidity of bridge construction, especially in the forming of "*light*" bridge; (ii.) How the weight of the pontoon will be affected by the structural principle involved in each case.

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In a pontoon designed for gunwale loading each side of the pontoon must be capable of acting as a girder in the event of the pontoon grounding and each girder must be capable of acting as a trestle, *i.e.*, it must be able to withstand as a dead load without permanent distortion the maximum weight which will be carried by the bridge.

In a pontoon designed for saddle loading with a central girder the central girder must be capable of fulfilling the same conditions as the two side girders mentioned above, but in this case only one girder is required, therefore a considerable saving in weight can be effected. The outside skin in this case can be considered merely as a " blister " required to give the necessary flotation though not to withstand any load when grounded, except that of the superstructure.

It is thought, on the whole, that a pontoon constructed on this central girder principle would be lighter than one constructed on the " two side girders " principle.

Saddle Loading versus Gunwale Loading.—For light bridges construction would probably be easier and more rapid with saddle loading (tests for this are being carried out at Christchurch), and the road bearers could certainly be shorter and considerably lighter, as in the gunwale loading it would not be permissible to consider the road bearers as supported at four points, owing to the rocking of the boat, *i.e.*, they would have to be considered as 20 ft. beams, supported at the ends only, as compared with 15 ft. beams similarly supported for saddle loading ; a very considerable reversal of stress would also have to be borne by the road bearers owing to the fact of their partial continuity.

There is also the difficulty of effecting a junction between the shore bay or trestle and the pontoon.

With " medium " and " heavy " bridges the same objections do not apply, as it is simply a question of whether the main saddle shall be carried on " short baulks " connecting the saddles of the two pontoons in the twin pier or on longer baulks (about 11 ft.) resting on the gunwales of the two pontoons in the pier and connected to the outside ones.

The trend of modern civil engineering is all towards " perfect articulation " as opposed to the " continuous girder " principle owing to the greater number of indeterminate stresses involved by the latter. Saddle loading produces the nearest approach to perfect articulation.

The difficulty of securing the roadway over the portion where the road bearers overlap was also considered a serious objection to the adoption of gunwale loading.

The balance of advantage would thus appear to be strongly in favour of saddle loading. See types of cross section under (*b*) above, and *Plate* I.

(*e*). A decking is considered necessary to provide against swamping

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in rough weather and in strong currents. The decking, which must, of course, be thoroughly watertight, should be of the minimum weight consistent with its ability to support men walking on it and to resist any sudden concussion to which it may be subjected, such as that produced by falling anchors, etc. The deck must also be provided with manholes to allow of men entering for repair and inspection purposes, and for ventilation against dry rot in the case of wooden pontoons.

In the case of uni-partite pontoons a transverse bulkhead should be provided at or near the centre, dividing the pontoon into two compartments.

(*f*). The handles should project as little as possible and should be incapable of in any way fouling each other when the pontoons are coupled together side by side in " medium " or " heavy " pier.

(*g*). Although when considering details of construction attention will still be paid to the desirability of minimizing the noise incurred during the handling of the pontoons and whilst they are in bridge, the additional noise that is likely to result from their being constructed of metal instead of wood is no longer considered sufficiently serious to justify disregarding the possible introduction of steel pontoons in place of wooden ones.

(*h*). The bows should be of such a form as to offer the least resistance to current, thus minimizing the anchor-pull and the liability of the bows to swamping.

The shaping of the bows will, however, be to some extent limited by the necessity for avoiding an undue reduction of buoyancy.

Plate III. shows various forms of bows for which tests are being carried out.

Fig. 1.—A medium-full bow with converging sides.

This is the best type for a stern, but not so good for a bow. Factor of resistance, 7·80.

The factor of resistance is the ratio between the actual resistance and the square of the velocity of current. The less this is the less resistful is the boat.

Fig. 2.—Semi-scow bow with parallel sides. The best type of bow as far as resistance and buoyancy together are concerned.

Factor of resistance, 7·20.

Fig. 3.—Scow bow and parallel sides.

This has the least resisting factor (6·80) but will not give the necessary buoyancy without adding appreciably to the length of the boat.

Fig. 4.—Full bows and converging sides, as in the present equipment pontoon. Factor, 8·82.

This causes much more resistance to the current than either of *Figs.* 1, 2 or 3.

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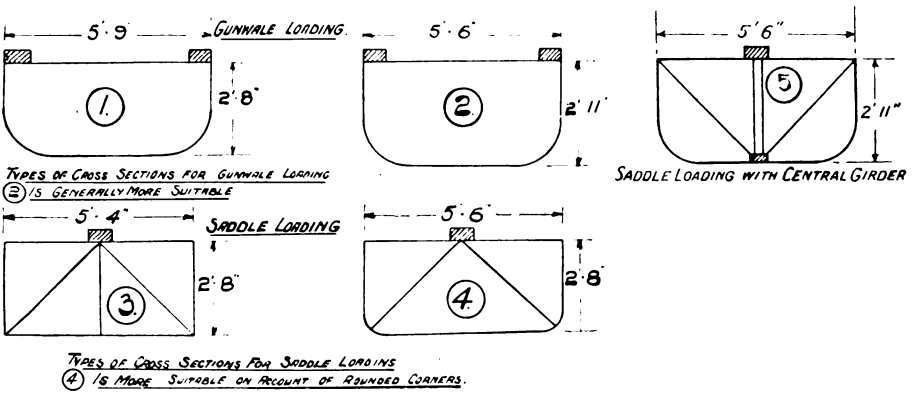
PLATE I.

CROSS SECTIONS OF PONTOONS.

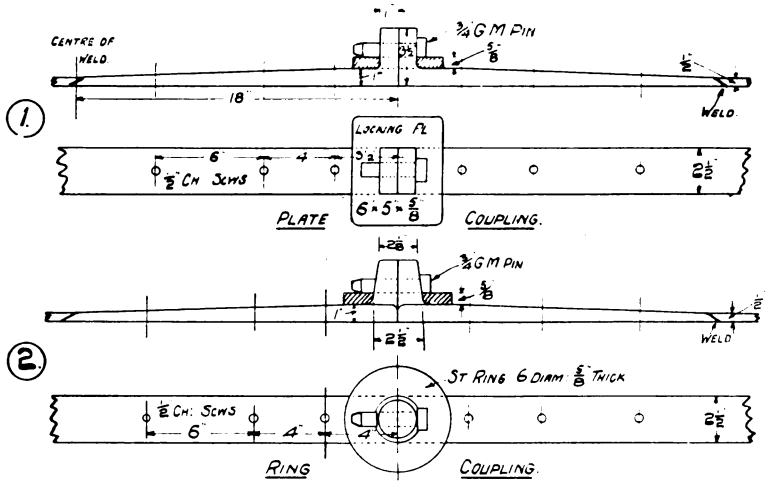


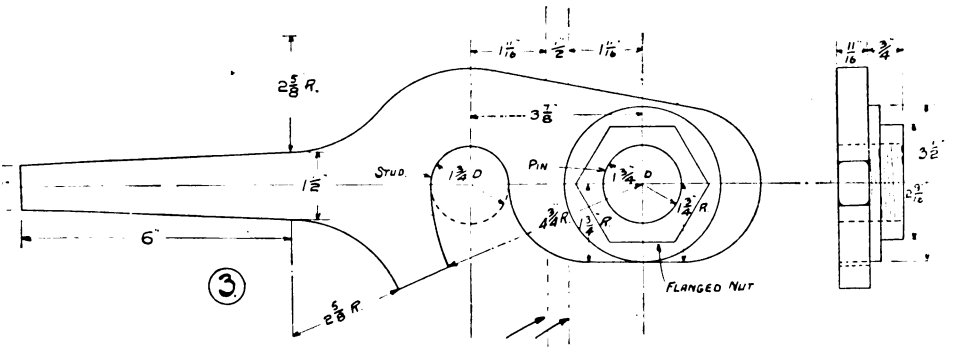
TYPES OF CROSS SECTIONS FOR GUNWALE LOADING
(2) IS GENERALLY MORE SUITABLE

TYPES OF CROSS SECTIONS FOR SADDLE LOADING
(4) IS MORE SUITABLE ON ACCOUNT OF ROUNDED CORNERS.

PLATE II.

TYPES OF COUPLINGS.





DOTTED LINES SHOW POSITION OF END PLATES OF PONTOONS.

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TYPES OF BOWS FOR PONTOONS.

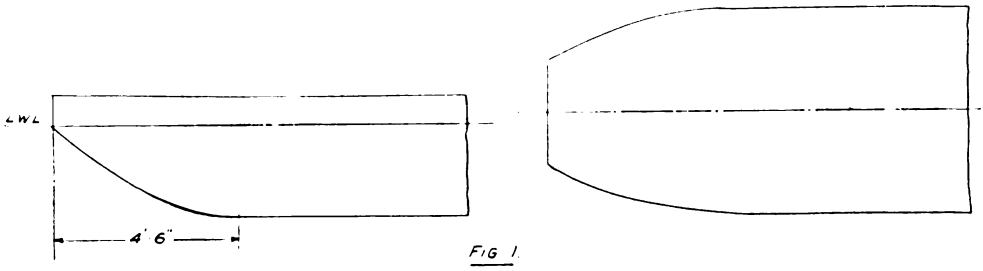

FIG 1.

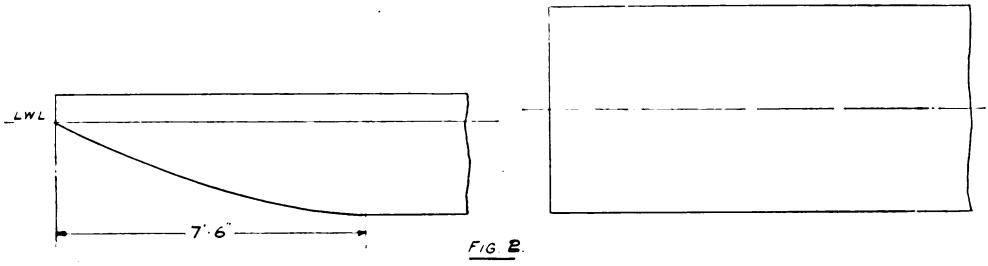

FIG 2.

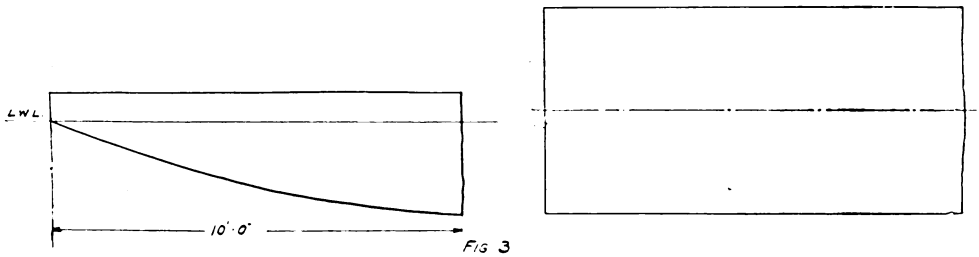

FIG 3

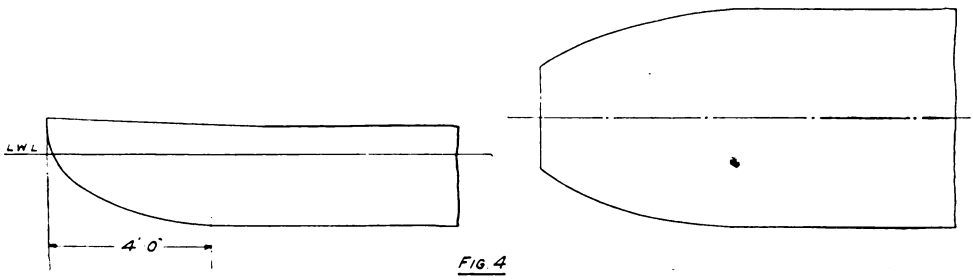

FIG 4.

ELEVATIONS. SCALE $\frac{1}{2}$" = 1FT PLANS.

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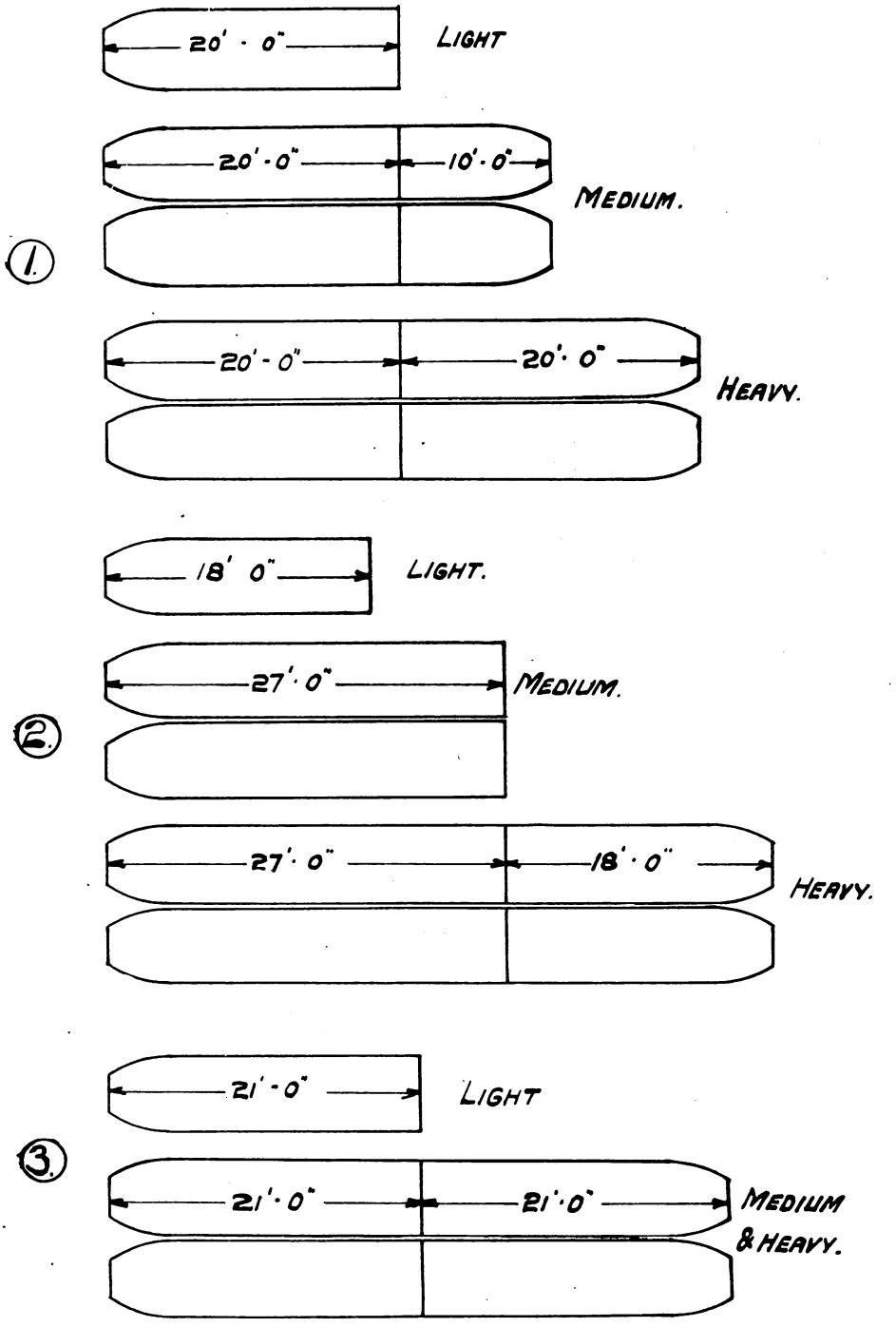
FORMS OF PIERS FOR PONTOONS.



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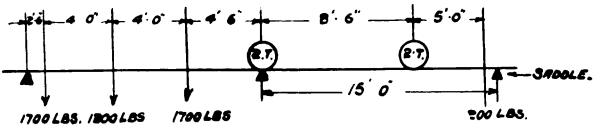
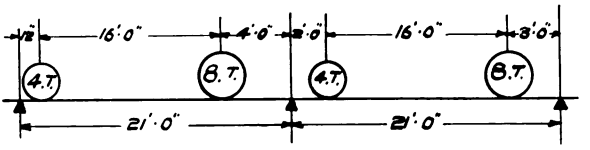
LOADS ON PONTOON BRIDGES.

FIG. I.



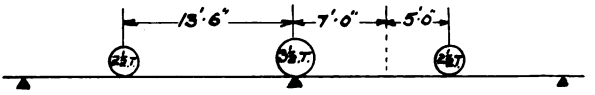
LIGHT BRIDGE MAX.M LOAD - AMM.N WAGON & LIMBER FOR 4·5 HOW.S DRAWN BY 6 LIGHT DRAUGHT HORSES.

FIG. II.



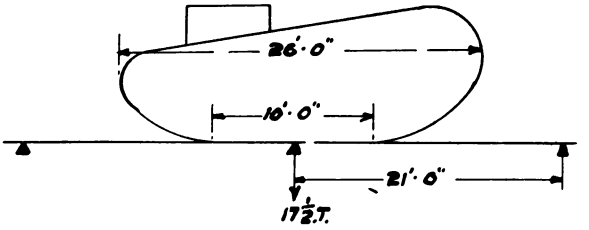
MEDIUM BRIDGE MAX.M LOAD. - FODEN LORRIES IN A STRING.

FIG. III.



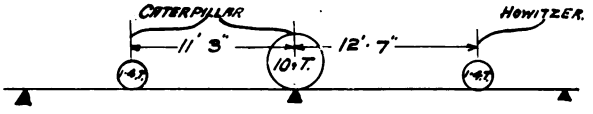
MEDIUM BRIDGE. NORMAL LOAD. - 3TON LORRIES IN A STRING.

FIG. IV.



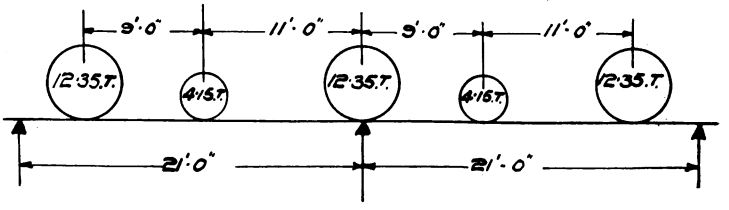
HEAVY BRIDGE. MAX.M LOAD - MEDIUM 'D' TANKS.

FIG. V.



HEAVY BRIDGE. NORMAL LOAD - 8" HOW.R DRAWN BY 11TON CATERPILLAR.

FIG. VI.



HEAVY BRIDGE. HEAVIEST AXLE LOAD - FOWLER STEAM TRACTORS.

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7. *Plate* IV. shows suggested varieties of lengths and grouping for forming the piers required for each class of bridge.

Fig. 1.—This grouping gives the minimum buoyancy allowable for "heavy" bridge, but necessitates the provision of a short length (10 ft.) of pontoon.

The couplings for "medium" bridge being eccentric to the centre of buoyancy of the pier are less stressed than if the point were in the centre.

Fig. 2.—This gives the minimum allowable buoyancy for "light" and "medium" bridge, but the 27 ft. boat is too long for transport on the present pontoon wagon, and a new wagon would have to be designed.

There are no couplings required for medium bridge.

Fig. 3.—This combines the "medium" and "heavy" types and gives 11½ in. freeboard for "light" loads, 15 in. for "medium" loads and 8 in. for "heavy" loads.

Only one length of pontoon is used.

This is considered the best grouping of all.

THE DRAINAGE MANUAL. (Third Edition).

By W. C. TYNDALE, ESQ., O.B.E., M.I.C.E., F.R.SAN. INST.

THE original Drainage Manual was written in 1890. It was the outcome of the general feeling at that time, that none of the works on the subject extant dealt with it in a comprehensive, concise, and sufficiently up-to-date way, so that those concerned with practical military sanitation might be guided as to what was considered to be the most suitable apparatus and methods for military purposes, from the subject of sanitary fittings and detailed drainage through the whole range to outfall sewers and sewage disposal.

Many officers of the Corps of Royal Engineers had already acquired considerable knowledge of these matters which had been gleaned from observation and study of works on the subject, but in those days the teaching and practice in the civil world was by no means uniform, with the result that ideas as to what was correct differed in the minds of those in charge of military establishments, and, in the putting in practice of these ideas by each succeeding officer in any station where reconstruction or remedies had to be applied produced the natural results.

The appointment of a civil sanitary expert in 1890 was considered to be a fitting opportunity for standardizing sanitary methods and putting an end to the somewhat chaotic state of affairs which had previously existed in connection with drainage arrangements. With this object the lately appointed expert was charged with the com-

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pilation of a Manual which it was hoped would meet the case. The work was written under the editorship of an officer of high position in D.F.W.'s Department.

There can be no doubt that the Manual so produced had an almost immediate effect, and as time went on it proved to be of great value and was appreciated throughout all ranks of the R.E. Corps, not only on account of the confidence it gave that conformity with it would be accepted as proper practice, but also because it was felt that methods and practice were standardized, so that wherever new work had to be carried out or alterations of old work had to be made, there was no doubt as to the lines on which such work should be based.

In the year 1907 a second edition of the Manual was published. This edition was felt to be necessary to meet the progress made in practical sanitary science. The edition was revised under much the same conditions of authorship as the original work, but with the added help of certain specialist officers and the Army MedicalAdvisory Board. Elaboration of minor subjects, and additions, were made, but an important new feature was the introduction of information on the artificial biological treatment of sewage, a process which during the past few years had made great strides, and had proved itself in some form or another to be thoroughly sound and acceptable for general adoption.

The progress in practical sanitary science in later years, and especially during the war, has again been great and the experience gained in connection with the vast number of camps constructed in 1914–18 has added much that is useful to the store of knowledge, more especially in connection with the purification of sewage and salvage of grease.

The new edition of the Manual lately issued treats fully of these last mentioned matters, and as regards these, and indeed in all subjects dealt with, may be considered to be quite up-to-date. There are two new Appendices, *viz.*, No. VI., on the "Working of the Horsfall Destructor," and No. VII., "Working and Maintenance of War Department Sewage Farms," the latter a very valuable addition. An innovation and improvement has been made in the revised order in which the various subjects have been placed. As pointed out in the "Preliminary Observations," these are in orderly sequence. This re-arrangement was made to be in co-ordination with the teaching at the School of Military Engineering.

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CORRESPONDENCE.

A NOTABLE GROUP OF R.E. OFFICERS.

To the Editor of the R.E. JOURNAL.

SIR,—On looking over some old photographs I came upon one taken in Simla in 1884 which I think is worthy of some comment in the *R.E. Journal*, on account of the evidence it affords of the influence of the Corps on Indian administration at that time. The group consists of 25 R.E. officers, including :—the Military Member of Council (Chesney), the Secretary to Government P.W.D. (Trevor, v.c.), the Director General of Railways (Stanton), the Director General of Military Works (Innes, v.c.), the Accountant General of P.W.D. (Filgate), the Surveyor General of India (Gore), the D.Q.M.G. for Intelligence (Bell, v.c.), the Chief Engineer, Punjab Irrigation (Home), the Chief Engineer, Punjab Roads and Buildings (Limond), the Secretary Defence Committee (Nicholson), the Engineer-in-Chief, Sind Peshin State Railway (Browne).

The enumeration of these appointments shows the variety and importance of the work being done by the Corps, mainly in connection with civil engineering works. Probably in that capacity the period in question gives the high-water mark of the R.E. in respect of the Indian Public Works. But it also shows that in some important military appointments R.E. officers were even then doing valuable work in peace-time, as they had done gallant work in war (it will be noted that there are three V.C.'s in the above list). This latter branch of R.E. work developed more and more, until in the Great War thirty years later, the Chief of the Staff and several divisional and brigade commanders were selected from the R.E.—a choice which hardly would have been made in 1884 in India. But the purely engineering element had to some extent declined.

Of the other officers in the photograph, mostly of junior ranks, five served with distinction in the late war, and received decorations :—Maxwell, Buston, Abbott, E. Hemming and Norton.

I am,

Yours faithfully,

G. K. SCOTT-MONCRIEFF, *Major-General.*

July 16th, 1921.

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NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 51.—*Earl Haig's Dispatches.*—Earl Haig's collected dispatches have been translated and are reviewed. The writer thinks them of considerable value, in spite of the restraint with which their author treats many important subjects, and evidently admires the competent and professional manner in which they are drawn up. He naturally takes exception to some points, particularly those which mention the numerical superiority of the Germans at different times, and says that to estimate relative strengths merely by counting the opposing divisions is misleading, because the German divisions were so much below establishment. He also finds it extraordinary that Lord Haig should still believe that he was making war for the preservation of civilization, and says that no one now doubts that the true motive was *Ceterum censeo Carthaginem esse delendam.* All German writers like to compare Germany with Carthage.

No. 52.—*The Military and Political Situation in the World.*— Holland is reducing her army considerably ; the yearly recruit class falling from 23,000 to 13,000 and the service from 8 to 6 months. On the other hand machine-guns are being considerably increased. The question of the Scheldt and the Limburg province is constantly being raised by Belgium, and naturally influences any projects for reducing the army. The Far Eastern question is followed with great interest, and the 40,000 strong colonial army is considered too weak to safeguard the immensely valuable Dutch East Indies. Their chief defence is, however, considered to lie in the jealousies of the Great Powers. The action of the Entente towards Germany is condemned, because it is feared that the collapse of Germany would be followed by that of Holland. Economic situation is bad and has led to disturbances. The eight-hour day and high wages have led to anxiety as to Holland's power to compete with foreign countries.

Switzerland.—The lessons of the war are being applied as far as circumstances allow. It has been agreed that the Army shall consist of six Divisions plus four Mountain Brigades, supported by three Divisions and two Brigades of Landwehr. Apparently infantry regiments are to come directly under Divisional command, Brigade Headquarters being done away with.

Eastern Siberia.—Semenov's position is said to have considerably improved and an advance towards the Lena River is expected. The *M.W.B.* says the Entente is doing its best to bring about his downfall,

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because he is against Wrangel and his policy. Kappel has died of typhus, but his troops form the 3rd Division of the Hetman Semenov. Chita has been taken from the Bolsheviks and Semenov's cavalry is pushing west and south of Baikal.

No. 1.—*French and German Officers.*—A German actor called Moissi, in an interview with a Norwegian journalist, said, "The French private soldier is a gentleman, but the French officer is just as much a swine as the German." *M.W.B.* is naturally furious and gets back on Moissi by giving some particulars of his career. He seems to have been commissioned in 1915 in the Flying Corps and to have seized his first chance to fly to Dunkirk, where he landed and gave himself up as a prisoner of war.

Regimental Associations.—These are going strong. At a re-union of one battalion of Bavarian artillery no less than 300 members turned up.

No. 2.—*The Death of the German Corps of Officers* is a complete *résumé* of the casualties suffered by the officers during the war. As already mentioned, 24 per cent. of the regular officers were killed (11,357 out of 45,923) and 15 per cent. of the reserve officers. In all the losses in officers amounted to 52,006 killed or died, while the grand total of all ranks, including about 14,000 coloured troops is given as 1,822,545. Regular officers serving on the outbreak of war lost 40 per cent. killed or died. Losses in other ranks were far less severe amounting to 15·4 per cent. During the war the strength of regular officers remained nearly constant, but the reserve officers were largely increased and the grand total increased from 49,051 on 1. 8. 14 to 164,823 on 10. 1. 19.

The Checho-Slovakian Officer.—A report published concerning a class of young officers of the Russian legion shows an extraordinarily low standard of education among them. They could hardly write, believed a triangle had four corners, and did not know what an angle was. As leaders they showed stupidity and lack of energy, and though they studied laboriously they made no progress. The only satisfactory point about them was their physical development; through years of idleness in various prison camps they have lost all power of concentration.

In Chains to Leipzig.—The German officers association sent a telegram to the Chancellor protesting against Lieut. Bolot of U-boat 86 being brought to Leipzig in handcuffs. Apparently this was done at the instance of German authorities.

No. 3.—*The Military and Political Situation in Great Britain.*—In this article, General Balck discusses the situation with which the Imperial conference had to deal. As regards the Anglo-Japanese treaty, he thinks that Japan will no longer be satisfied with the clause which allows England to remain neutral in case of war against America, and that the proposed inclusion of America in the alliance is out of the question. He considers that the situation in the Near East makes it very desirable for England that the treaty be renewed. He speaks of the much-discussed Russo-Turkish *rapprochement* as if it were a *fait accompli*, and foresees much trouble for England accordingly. The situation on

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the N.W. frontier also pleases him immensely and he attributes all the recently introduced (though long projected) Indian legislative reforms to the direct pressure of existing conditions ! His forecast of events in Ireland has, so far, proved fairly accurate. The reduction of the British fleet is, he thinks, foolhardy, but he admits that lack of money compels it. Bernard Shaw's forecast of war with America and Japan is taken quite seriously.

The Leipzig Trials.—The *M.W.B.* compares the attitude of the French towards the results of the Leipzig trials with the view they take of their own court-martial results. The latter have, in several instances, been recently reviewed and found to have been faulty ; but the French Minister of War says that mistakes are bound to happen in war, and that after this lapse of time it is impossible to fix responsibility. The *M.W.B.* says that this is the view that should have been taken of the Leipzig results. On the whole there has been very little comment on Leipzig in the *M.W.B.*, though violent counter-charges against the French have been fairly common.

Reduction of Pensions.—The law which lays down that pensions shall be reduced if the pensioner has any other income is, naturally, severely criticized. The writer says, truly enough, that work must now be reckoned an expensive luxury ; and, since a number of officers will now no longer be able to afford it, the economy of the country will suffer accordingly. He says that already it is unfortunately a fact that many ex-officers are engaged in illegal trading of various descriptions, and that this law will add to their number.

No. 4.—*The Military and Political Situation.*—French recruiting difficulties are discussed, as well as France's probable attitude towards any proposals about disarmament. *M.W.B.* does not think she will do much in that way, since the fear of Germany is too deeply branded on her. A comment on the trial of Lieuts. Dittmar and Boldt, of U-boat 86, is surprisingly moderate in tone. It says that, though they could almost always assume that hospital ships were carrying munitions, in this particular case they were wrong ; and the punishment, though most excessive, is not altogether unjustified. The honour of the officers is however untarnished.

The Army Council of Delegates.—This seems to be working satisfactorily and held its third meeting in July. Among other subjects the following were dealt with—Insurance, marriage of officers, punishments and many points of interior economy. As already stated, this Council, which is composed of all ranks, has advisory powers only.

The Reckoning.—This is the title of a book which purports to summarise the atrocities committed against Germans. It is, of course, intended to prove that the only cruelties in the war were those committed by Germany's enemies, who now have the effrontery to accuse her of acts against the law of nations.

L. CHENEVIX-TRENCH, *Major, R.E.*

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REVUE MILITAIRE GÉNÉRALE.

January & February 1921.

The Revision of the Regulations (*continued*).—From the tactical point of view imperfections of method became evident to the French command from 20th August, when all armies were warned (*a*) of the preponderating effect in battle of modern firearms, more especially of the machine-gun, and (*b*) of the lack of co-operation between the artillery and infantry. The teaching of the *Service des Armées en Campagne*, that "artillery no longer prepares the attack, it supports it," is at variance with the requirements of warfare. In forbidding "preparation" the regulations intended to put a stop to the *artillery duel*, but that the necessity was recognized for destroying by artillery fire everything tending to impede the advance of the infantry is definitely shown in the report forwarding the regulations to the Minister for War. Possibly here too may be found the reason for the insufficiency of heavy field artillery which became so evident early in the war. However that may be, the artillery must be well acquainted with the action and needs of infantry, which raises the problem of inter-communication, a problem not yet solved. The note of 20th August also pointed out (*c*) that the lateral intervals between the individuals in attack formations should be wider, and that the firing lines should be continuously fed from similarly extended formations in rear. (*d*) Sufficient attention was not being paid to the instructions in the F.S. Regulations in respect of field fortification. The German organized position on the Aisne was a surprise though the trenches had only been hastily dug; they were, however, covered by considerable stretches of wire entanglement. (*e*) Cavalry must be supported by infantry, as the German cavalry by retirement endeavoured to entice the French cavalry under infantry fire. More rest must be allowed to the horses to eat and sleep.

Second Period.—The fronts now extended from Belfort to the North Sea, and the Germans, realizing that their outflanking efforts had failed, struck at the coast ports—Ypres, 22nd October, and Dixmude, 13th November—but without success, their second great check. In these battles the Germans suffered heavy casualties due to attacking in too dense formations troops sheltered by at least elements of trenches, just as the Allies had suffered on the Aisne.

Third Period.—During the winter the French were learning that the war was not destined to be finished out of hand. Gradually it was realized that a period of siege warfare was inevitable, and little known special regulations were being studied. These indicated that infantry must be turned into sappers, and artillery into siege units, facts foreign to preconceived ideals. Heavy guns were dragged from fortresses and coast defences, but were too few in number, and none were quick-firers. Further supplies of the same patterns, ammunition, and additional machine-guns were put in hand as quickly as the small means of production allowed, but heavy quick-firers were not yet thought of. The period can best be considered in two phases, first, the local attacks on the German

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positions of the winter, and second the French offensives in Artois in May–June, and in Champagne–Artois in September, 1915. It must be remembered that the enemy held only a first position of two or three lines of trenches. Mining was attempted in favourable situations, and the Germans introduced asphyxiating gas. At the end of the first phase, on 2nd January, 1915, a fresh series of instructions was issued to the effect that attacks must be slower and more methodical, must be arranged beforehand to the smallest detail, and preceded by a formidable artillery preparation. Attacks must be as numerous as numbers would allow of, and delivered simultaneously at various points in the line on as wide fronts as possible to prevent the enemy concentrating on one point, and be prolonged to the flanks by fire calculated to destroy the enemy flanking fire. As the artillery could only bombard one line of trench at a time the attack must be in a succession of waves, and the infantry must avoid strong points until they had been effectively dealt with by the artillery. Captured trenches to be at once organized against counter-attack. The instructions were sound in view of the insufficiency and slow fire of the artillery, which entailed lack of depth in the preparation, delay in precise ranging on the next objective, and consequently long waits between the successive waves of the attack. Under such conditions the battle of Perthes opened (15th February). Want of artillery (100 heavy guns only) limited the front to seven, then to three kilometres. According to the German account, the attack might have succeeded if it had been resolutely pressed home, but, the preparation had not included the artillery position, and such a heavy cross fire was brought to bear on the narrow salient that it could only be held subject to terrible loss of life.

On 16th April a fresh set of instructions enjoined rapidity and continuity in the attack, which must be pressed right through the position to prevent the preparation of counter-attacks and the establishment of a position in rear. Artillery must be as far to the front as possible for counter-battery work, and to accompany the infantry by a barrage, and must be prepared to change position as the attack advanced; ranging was to be assisted by balloons and air-craft. The infantry attack would be preceded by three or four hours' preparation by the heavy artillery, and then by about ten minutes' bombardment of the enemy by all calibres. During the attack there would be an artillery barrage in front, and a bombardment of the next line of trenches Divisions would attack on a front of 1,000 to 1,200 metres, and be organized in depth so that they could hold out for several days. Here again the weak point was that lack of artillery would not allow of the scheme being carried out on a sufficiently wide front, and if the trenches were to be bombarded successively there were no guns for counter-battery work, and the enemy artillery would be free to fire on the infantry. It should be noted that the normal extension of one man per metre for the infantry was adhered to.

During this winter the French field defences improved considerably, supports and reserves entrenched themselves, trenches were deeper, and firing platforms were made, at least the busy sectors of trench were continuous, and communication trenches were constructed by degrees.

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Meanwhile the Germans, better trained in the defence, and determined to trust to it, had been constructing deep bands of entanglement, concrete shelters, flanking casemates, covered communications, etc. A second position had not been completed, but was commenced early in 1915.

A. R. REYNOLDS.

REVUE MILITAIRE SUISSE.

No. 3.—*March,* 1921.

The Strategical Position of Switzerland as a Member of the League of Nations.—Colonel Feyler points out in the original article that the authors of the Pact of Nations in no way claim to have brought into existence the reign of a universal and perpetual peace; their object has been to increase the length of the periods which separate "explosions of hate." It is recognised that, in the future, there may be "private" wars which may be waged without in any way implicating the League of Nations; wars which cannot be prevented by the machinery at the disposal of the League. Colonel Feyler deals briefly with the manner in which Switzerland, in view of the provisions of the Treaty of Versailles, is likely to be affected in the case of such "private" wars. The signatories of this Treaty have declared that the neutrality of Switzerland guaranteed by the Treaties of 1815 is to be "maintained in the interests of general peace." It is pointed out that the fundamental character of the neutrality imposed on Switzerland in 1920, which, by the way, is different to the former "perpetual neutrality"—affects alone, and is limited to, the movement of armies. In other respects Switzerland is not required to be a neutral, for she will in future espouse the cause of the League of Nations. Consequently, she will, in the event of a war, have to break off diplomatic, financial and commercial relations with the "enemies" of the League, and take part in an economic blockade of them. Switzerland will naturally retain friendly relations with the other members of the League, who will provide her with essential supplies, and with them alone she will, during a state of "private" war, continue to maintain commercial relations. Switzerland will thus occupy a somewhat anomalous position in the event of future hostilities in which the States on her borders may participate. Colonel Feyler deals in his article with the problem of the mobilization of the Swiss Army in the event of Switzerland occupying a position analogous to that in which Belgium found herself in August, 1914. Five sketch maps accompany the text of the original article, showing respectively the concentration areas first occupied by the French armies on the violation of the Belgian neutrality in 1914; the concentration areas of the German, French, and British armies during the first half of August, 1914; the positions of the Belgian Divisions on the 3rd and on the 5th August, 1914; the territorial areas assigned to the Swiss Divisions in 1912. (*To be continued.*)

The French 9th Corps at the Marshes of St. Gond.—An article on the above subject begun in the number of the *Revue* for January, 1921,

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is concluded in the number under notice. In this part of his article Col. Poudret deals with the operations on the right wing of the French 9th Corps. The narrative shows by how narrow a margin it escaped defeat. Indeed, it was the tenacity of purpose of General Foch and the skilful dispositions made by him when the battle began which saved the situation; it was fortunate, too, that he was so ably seconded by his Divisional Commanders and an energetic staff.

The Morale of the Army and Memories of the Mobilization.—Major de Vallière deals in the original article with the disaffection which existed in some portions of the Swiss Army during the period of its war mobilization, and traces the causes which were responsible for the unhappy state of affairs which prevailed at one time. Fortunately, the disaffection was not at all widespread, as is evidenced by the great number of pamphlets and other publications, giving the history of the mobilization period, which are being published in Switzerland at the present time.

NOTES AND NEWS.—*Switzerland.*—Lieut.-Colonel Corda, Professor at the Artillery School, Fontainebleau, has been giving a series of lectures at Zurich to the officers of the Swiss Army on the practical aspects of the Great War. These lectures have included subjects such as the handling of reserves, the use of railways and automobiles, the minutiæ of preparations for a counter-offensive, the wastage of war, flexibility of command.

Belgium.—The question has recently been under consideration as to the minimum period necessary to train a recruit. It is now recognized that the drafting of men to the front after only five to six months' training, during the early days of the war, was a mistake; although in many cases such drafts were well reported upon, they did not always meet all the requirements of war. It has now been decided to provide a ten months' course of training for the infantry, a twelve months' course for other arms and services, except cavalry and horse artillery, for which the course has been fixed at thirteen months.

France.—The suggestion is on foot to deprive infantry captains of their mounts; General de Maud'huy is said to be the proposer of the scheme.

W. A. J. O'MEARA.

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A FRONTIER MOTOR ROAD.

By MAJOR A. H. BELL, O.B.E., D.S.O., R.E.

"LORD Montagu of Beaulieu on Tuesday in the House of Lords asked for information about the North West Frontier, which is still disturbed. He urged the Government to improve the roads and to extend the railways, so that by the use of motor and rail transport the garrisons might be more easily supplied than they are now when long and unwieldy camel caravans invite attack from raiders."

The above appeared in a well-known periodical a few weeks ago. No one will dispute the aptness of Lord Montagu's remarks, except perhaps the Finance Member of the Government of India.

About six years ago it was recognized that there were better ways of moving supplies from one place to another on the Indian Frontier than on the backs of camels or mules or in two-wheeled carts drawn by oxen. It is true that the camel or mule does not require an elaborate road and can walk through shallow streams, but the normal pace of a camel, which is the primary means of transport on the Frontier, is only two to three miles an hour, his useful load is 400 pounds, and his normal day's journey is about fifteen miles. The camel and his attendant require food which has to be carried. The Army Transport cart carries 800 pounds, the two animals that draw it and their driver require food, and the pace at which it travels is about the same as that of the camel.

The humble motor vehicle known on the Frontier as a Ford vanette weighs unloaded 13 cwt.; its useful load is 800 pounds; it is driven by one man; it can carry its load 40 miles or so and come back the same day. It requires a track of some kind, but not a very elaborate one. It is not far wrong to say that a Ford vanette can carry double the load a camel can, five times as far, and return to its starting point the same day. On this basis it may be said that for transport purposes a Ford vanette is worth 10 camels.

Apart from considerations of transport capacity motor vehicles on the Frontier have other obvious advantages over four-footed animals. The motor vehicle is by reason of its speed less vulnerable

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and less likely to be disabled. A Pathan would have some difficulty in starting up and driving off a motor vehicle at night, but appears to have none whatever in stealing half a dozen camels from inside a barbed-wire enclosure. The weight of stores required to keep a motor vehicle on the road must be far less than the weight of food for the equivalent number of camels.

The policy of making roads for mechanical transport in the North West Frontier Province from railhead towards the Durand line is now a well-established one, and a programme exists which will take many years to complete.

For nearly three years I was concerned in the making of one such road, and possibly a short description of the work may be of interest not only to the R.E. officers who in the hot weather of 1897 took three days to perform a journey which can now be performed in less than half that number of hours, but also to others who would appreciate a job more interesting than that which usually falls to the lot of the D.O. in the British Service.

One of the recognized routes between India and Afghanistan is that which begins in the Tochi Valley. The country at the source of the Tochi is unsurveyed and the river is there shown in the map by dotted lines. Probably no European has ever been to Afghanistan by this route.

In neither the first nor second Afghan Wars was the Tochi Valley used as a line of advance into Afghanistan. For all that the motor road which now starts from Bannu may one day be continued beyond its present head at Dardoni and end up at Ghazni.

The Tochi Valley first became of interest to the British Empire when Bannu was occupied after the Sikh wars. The house John Nicholson lived in is still the Deputy Commissioner's bungalow, and a man who was John Nicholson's bearer died only a few months ago.

Bannu stands on the right bank of the Kurram River at a point about eight miles from the Tochi. It is about 50 miles due west of Mari Indus, which is at the railhead on the left bank of the Indus. A steam ferry plies between Mari Indus and Kalabagh opposite to it on the right bank. From Kalabagh a narrow-gauge railway-line runs to Bannu, but not in a straight line; it describes roughly speaking a semicircular route eighty-six miles long before it reaches Bannu; at the most southern point of the semicircle is Lakhi Marwat, from which a branch goes south-west to Tank, the starting point for two other frontier roads, one up the Tank Tarn into Mahsud country and one up the Gumal, another route into Afghanistan and one much used by nomad frontier tribes.

This narrow-gauge line which connects Kalabagh with Bannu and Tank, was finished about the end of 1915. (Previous to that Bannu was reached by seventy-eight miles of road from Kohat).

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Like many other things in India it was constructed cheaply rather than efficiently. It does not afford a reliable means of communication. As a matter of course every August certain portions of it were washed away. In 1919 I walked over three miles of country smooth as the sea shore. The railway-line was lying twisted and bent a few yards away and broken lumps of brickwork and stray girders bore witness to the bridges and culverts which had once been there.

A railway-bridge at Kalabagh over the Indus was begun last year, and when a broad-gauge line has replaced the narrow-gauge, communication between the Tochi Valley and India will be easy.

For many years after Bannu was first occupied British influence was not felt in the Tochi Valley. In 1872 a punitive expedition was carried out against the people, called Dawars, who inhabit the lower Tochi Valley. It comprised about 2,000 men of six different units and two howitzers. The column went about 30 miles from Bannu up the valley and the operations were all over in two days. It is recorded that ammunition wagons as well as the howitzers accompanied the column, so it must be supposed that some sort of road for wheeled traffic was made, probably a clearing up the river bed.

In 1894 and 1895 in the operations against the Mahsuds, whose country, roughly speaking, lies between the Tochi and Gumal Valleys, the Tochi Valley was one of the lines of advance. These operations were the outcome of an attack by Mahsuds on the British camp at Wana.

In 1895 the lower Tochi Valley was practically annexed by the Government, and a military force was established at Miranshah, thirty-nine miles from Bannu, with posts at Idak and Saidgi, twenty-seven and fourteen miles from Bannu respectively. Saidgi was the first stage, Idak the second and Miranshah the third stage on the road up the Tochi. In the autumn of 1896 civil and military headquarters were moved to Datta Khel, which is 25 miles beyond Miranshah.

On June 10th, 1897, occurred the treacherous affair at Maizar, from which incident arose the Tochi expedition in the hot weather of 1898.

The intermediate stage between Miranshah and Datta Khel is at Boya, at which point the track crosses the Tochi River. Normally a shallow stream whose waters are fed from the snows of Afghanistan, in times of heavy rain it becomes a mighty torrent impassable sometimes for days together.

A military force remained in the Tochi until the Northern Waziristan Militia took over the guardianship of that part of the frontier

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about 1891. Militia Posts were built at intervals along the Tochi Valley between Bannu and Datta Khel, the first being a small block-house at Marzail, nine miles from Bannu near the boundary line of the North West Frontier Province.

In 1901 and 1902 columns again operated in the Tochi against the Mahsuds.

In 1915 a military force was sent to Miranshah to repel an army of tribesmen which entered the Tochi Valley from the district of Afghanistan called Khost, which forms a salient in the eastern boundary of that country north of the Tochi. A battle in which the slaughter was greater than is usual in frontier warfare was fought near a village called Dardoni, and the remainder of the tribesmen quickly returned to Khost. The military force remained at Miranshah and settled down in an unhealthy camp made under the walls of the militia post. This camp was in 1918 replaced by a more commodious and sanitary one on the plain a mile beyond the post and is known as Dardoni. It is now provided with electric light and fans, a piped water-supply and an ice factory, in fact with all the luxuries which one can reasonably expect outside British India.

In 1917 took place the fifth organized expedition against the Mahsuds, the main operations were conducted from Tank, but the force at Miranshah was strengthened and mechanical transport was used for the first time (without counting a few touring cars) on the Tochi Road. Active operations in the Tochi Valley were limited to the capture by stratagem of a Militia Post near Datta Khel by some Mahsuds, two of whom disarmed suspicion by disguising themselves as women.

On May 6th, 1918, the third Afghan War began ; we evacuated the Upper Tochi, burning the Militia Posts as we retreated and concentrated at Miranshah.

The false impression of weakness produced by this retirement and the ties of religion and kinship proved too strong for the loyalty of the Militia. They deserted in gangs (chiefly Afridis), taking their rifles with them and setting fire to their posts. One large and four small Militia Posts were abandoned in this way, and for about a fortnight Miranshah was cut off from Bannu, and the post at Idak isolated. Reinforcements soon arrived, and on the opening of the lower Tochi the burnt-out posts were soon repaired.

In the autumn of 1919 a considerable force was concentrated at Dardoni and advanced to Datta Khel, where our terms were given out to the Wazirs, who had thrown in their lot with the Afghans, and were accepted. The column then returned to Miranshah. Mechanical transport was again used in the Tochi for supplying this column, but was withdrawn with the column to Tank for operations against the Mahsuds.

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The first metalled road up the Tochi was begun about 1900. It was good enough for light two-wheeled vehicles, but in many respects fell short of the ideal motor road. The alignment was with three exceptions satisfactory, and there were no gradients steeper than about one in fifteen. Culverts however were far too few, and what there were were mostly too small. Two narrow irrigation canals had been bridged, but no attempt had been made to bridge any of the wider nullahs, though there were several at which traffic used to be held up for many hours, during the prevalence of heavy rains. The metalling, which was in many places nearly worn out, was only nine feet wide and there was no soling. There were several very sharp salients and re-entrants. In many places metalling had been laid on the natural surface of the ground without any banking or cutting.

The most important points of the specification for mechanical transport roads as issued from Simla were briefly as follows:— Metalling was to be 12 ft. wide and 6 in. thick over 6 in. of soling; with an earth berm 6 ft. wide on both sides. The width of metalling was later altered to 16 ft. with a 4-ft. berm on both sides, but not till after many miles of the 12-ft. width had been laid. The metalling was to be laid in two thicknesses of 4½ in. consolidated to 3 in. Soling was only to be laid where there was not a sufficient thickness of old metalling left to form a foundation for the new metalling, or where the natural soil was not sufficiently hard. Culverts were to be 20 ft. wide between parapets. All nullahs were to be bridged in cases where serious delay from floods might result. In other cases causeways were to be made. The width of bridges between parapets was to be 16 ft. The steepest gradient allowed was, I think, 1 in 12, but I made nothing steeper than 1 in 15.

With two exceptions which will be described later the alignment of the old road was followed and the new metalling was laid on top of the old, the extra width being obtained by laying a foundation of soling on both sides of the old metalling. Every opportunity was taken of eliminating unnecessary minor curves by putting the increase in width sometimes on one side and sometimes on the other or partly on both. With very few exceptions all the old culverts had to be rebuilt and many new ones added, and in connection with the latter many small embankments had to be made. Small undulations were removed by banking and cutting. In all hill sections much cutting had to be done to obtain the increased width.

I will now give a short description of the country the road passed through, and of the more interesting works carried out.

For five miles from railhead at Bannu the road traverses an almost level stretch of heavily-cultivated land irrigated by water from the

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Kurram River. The soil is "putt," a mixture of sand and light clay very easily eroded. To facilitate irrigation many culverts are necessary. At a point five miles from Bannu a wide nullah, called Baran, is crossed. It is normally dry, but is filled by an impassable torrent after heavy rain. A bridge consisting of five spans, each about 86 ft. long, made of old railway girders, was constructed over this nullah. The piers and abutments were made of brick, the roadway was of ferro-concrete slabs laid straight on the cross girders. The right bank was well defined, but the left bank was subject to erosion at every flood. The left abutment was therefore built well out into the nullah and the bed confined by a long training bund of stone pitching based on a lime concrete drop wall carried down below the calculated depth of scour.

The character of the soil changes about this point from the light "putt" to a hard gravel in which big boulders are embedded, forming an excellent foundation for metalling. For the next four miles the road runs over a barren stony plain, past an aerodrome and landing ground at mile six, till about mile nine it crosses the boundary line between the North West Frontier Province and the territory beyond which is administered by Political Agents. The road gradually rises to this point and then drops suddenly to the Tochi River bed, which it follows for the next ten miles. For the first five miles the foothills in the left bank are a mile or so from the river, and the road is on the undulating plateau between. At 11½ miles from Bannu a small bridge of three 20-ft. arches was made, replacing a paved causeway which had been partly destroyed by floods. The arches themselves were made of moulded concrete blocks. Whilst this bridge was in course of construction a sudden flood washed away and drowned two *badraggas* (Pathan guards) who had taken shelter from the rain under the arches. As the right bank of the nullah was very vaguely defined, a long embankment was made on this bank as an approach and a rough stone wall built to guide the flood under the arches.

At about 14 miles from Bannu the hills on both banks close in on the road, and form a gorge. On the top of the hill about 200 ft. above the river is the Saidgi Militia Post, overlooking the river at the edge of a small plateau. The R.E. officer who originally laid out the road (then Lieut. G. P. Campbell, R.E.) had wisely chosen an alignment over the hill on this plateau; but the engineer who constructed it had taken it at the bottom of the hill at the very edge of the river a few feet above high-flood line. On August 1st, 1917, the summer rainy season opened with a violent storm. I tried to take a car along the road the next morning, and found it covered in places with several feet of mud and large boulders, which had poured down the steep hillside in avalanches at every place where a watercourse could form.

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I decided that a road at the foot of the hill was to be avoided if possible and put up a scheme for taking the road over the plateau, down the face of the hill, over a small gorge, on a 45-ft. bank over another small plateau and back to the old alignment. This deviation from the old alignment was a little over a mile long, and had the advantage of affording direct access for vehicles to the plateau on which the Militia Post stood, an excellent camping ground for troops passing up the road. The new road down the face of the hill was at a slope of 1 in 15 ; in order to make it straight, a great advantage on a steep incline, two small depressions in the hillside were blocked up with dry stone retaining walls. The larger of the two was over 40 ft. high in the middle and 11 ft. 6 in. wide at the bottom, and had an outer batter of four in one. Good limestone was used for the face and softer sandstone, which appeared in outcrops in the locality, was used for the inside. A cutting 19 ft. deep at its worst, had to be made at the top of the hill, the soil being hard gravel with huge boulders embedded in it. The bank, 45 ft. high at the bottom of the hill, was made on the top of a long bridge consisting of two 15-foot arches. The arch rings were made of a concrete in which lime and cement were mixed in the proportion of 4 to 1, the aggregate being river gravel. The mixture was satisfactory and set quickly.

The aspect of the Tochi Valley about this locality is wild and rugged in the extreme. The strata have been tilted up vertically, so that within a few yards a variety of soils and rocks are met with. On both sides of the river are stony hills intersected by numerous watercourses which afford a safe means of approach to raiders and outlaws coming from the north to attack convoys or cut off a picket. For this reason the road between Saidgi and Khajuri, the place 20 miles from Bannu where the road leaves the Tochi Valley, is more liable to attack than any other part.

At a point about 16 miles from Bannu the Tochi has apparently cut through a vertical stratum of rock ; the width of the river bed at this point is about 210 ft., though in many places above and below this point it is over 600 ft. wide.

Upstream of this vertical band of rock the left bank for a distance of about 400 yds. is formed by an almost vertical precipice of solid clay. The old road had been cut at the foot of the slope and ran at a height of 40 ft. or so above the river bed. Half a mile further on, an under section of a lofty hill called Shinkai, projecting towards the south, had forced the river to describe an elongated loop ; the road leaving the river bed had naturally been taken over the kotel at the head of this loop, and met the river bed again on the other side.

The road at the bottom of the clay slope was in a most precarious position. The clay softened under the action of rain and slid down

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the hillside in avalanches, submerging the road ; at the same time the river bank itself below the road was liable to erosion by the river when in flood. In fact a short length subsided bodily a few years ago, and wheeled traffic was cut off for several days.

To make a satisfactory motor road it was necessary to avoid this alignment altogether, and as it was impracticable to take the road over Shinkai Hill, it was decided to bridge the Tochi twice and make a diversion on the right bank. This necessitated the construction of two fair-sized bridges. The lower of the two, known as Lower Shinhai Bridge, was made at the point where the Tochi had cut through the vertical stratum of rock. It was made of old railway girders and took the form of two cantilevers with a suspended span in the middle. The span between the two piers was about 208 ft. The approach to the bridge on the right bank involved the cutting of a road along an almost vertical rock face for about 150 yds.

The upper of the two bridges is also of old railway girders in three spans. It was not finished at the time I left the Tochi. The approach to this bridge on the left bank involved much heavy cutting near the kotel which the old road had made use of.

The alignment of the old road between Shinkai kotel and Khajuri needed no alteration except for the elimination of two bad salients by through-cutting.

A new bridge of 64-ft. waterway was made to replace a culvert of 12-ft. span over a nullah called Clinai, about 17 miles from Bannu. A tonga was caught by a sudden flood in this nullah whilst the bridge was being built and a pony was drowned. The bridge was made of I rolled-steel girders with ferro-concrete slabs on the upper flange. Six inches of earth, and the same thickness of soling and metalling, was laid on the slabs.

At Khajuri there is a fair-sized Militia Post, and a landing ground for aeroplanes on the hill overlooking the river. The hillside is full of springs ; green patches of cultivation and numerous palm-trees form a pleasing contrast to the awful desolation of the Saidgi defile.

Below the hill on which the Militia Post stands a fair-sized nullah with a perpetual flow of water meets the bank of the Tochi. A bridge of eight 19 ft.-6 in. spans was made over this nullah. Like the bridge mentioned above, the piers and abutments were made of limestone spanned by rolled-steel girders with a ferro-concrete slab on top. A long embankment had to be made to form the approach on the Bannu side.

The old crossing had been by a causeway, *i.e.*, a flat paved or concreted surface about 12 ft. wide on a level with the river bed. Unless very carefully made, any causeway may at the worst be washed out by floods, especially at the two ends, or at the best have a deposit

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of stones or mud left on it by the retreating waters. This particular causeway being at a point about half-way between Bannu and Miranshah was a favourite spot for watering animals. One can now cross the nullah on a level road at 30 miles an hour, where formerly one had to jostle one's way through a struggling crowd of tonga ponies, camels, bullocks and donkeys, an operation in which much time might be lost.

At Khajuri the road leaves the Tochi and, after climbing a steep hill from the bridge, traverses a wide plain for about seven miles until Idak, the next Militia Post, is reached. Parts of this plain are heavily cultivated, irrigation water being obtained from the Tochi. For three miles the road runs through cultivation, and many old culverts were rebuilt. Except in the cultivated areas where the soil is " putt " it is generally speaking a hard gravel.

Between Idak and Miranshah the distance is twelve miles, a stretch of absolutely barren country. Eight miles from Idak the road has to cross a long rocky spur by a pass called the Isha Narai, but before reaching this hilly mass the country is fairly open.

About a mile beyond Idak the road crosses a wide and straggling nullah bed of a kind which is typical of the frontier. The bed is dry except in times of heavy rain, when it becomes quickly filled with a raging torrent. The banks are well defined where the nullah leaves the foothills, but as it reaches more open country one or both its banks become less and less distinct, until it would be hard to say where dry land ends and nullah bed begins.

In this particular case the left bank was well defined, but was gradually being eroded as the main force of the current inclined towards this side. The total width at the road was about 1,200 ft., although a mile higher up it was but 500 ft. There had been a paved causeway over the deepest part of the bed near the left bank, but it had met the usual fate of such works when carelessly constructed, and had been outflanked at one end and partly washed away in the middle. A bridge of 20 arched spans of 20 ft. each was made on the old alignment. The piers and abutments were of local limestone, three of the arches were made of bricks burnt on the spot, but the proportion of bad bricks turned out of the kilns was so large that the remaining arches were made of cement concrete with a camouflage of brick on the exposed faces. A training bund was made along the left bank to prevent further erosion at right angles to the bridge, and a similar bund on the right bank, the upper end turned back in a curve to guide the stream towards the bridge. The total width of waterway between the bunds was about the same as the width of the nullah a mile higher up, where both banks were well defined.

From this bridge for the next eight miles the road gradually rises

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till it approaches the Isha Narai by a steep and winding ascent containing five bad re-entrants. The hills in this locality were of a particularly hard kind of grey-blue limestone.

A better alignment for the road exists through a gap which is some 200 ft. lower then that which was selected, but the expense involved would not have justified an alteration.

From the Isha Narai the road descends rapidly to a nullah called Chasmai, 36 miles from Bannu, in which there is a perpetual flow of water. The crossing of this nullah had been by a causeway which was rendered impassable by floods just about the same time the bridge was finished. The site for the bridge was fixed about 500 yds. above the causeway, where an outcrop of rock which formed an excellent foundation for the right abutment seemed to cross the river bed. This necessitated an entirely new piece of road as an approach to the left end of the bridge, entailing much blasting through a kopje of very hard limestone, and a small 15-ft. arch over a side nullah. The right end of the bridge was made to coincide with the apex of a particularly bad salient on the old road.

The bridge was built of six spans of old pin warren girders, each about 65 ft. long, on piers and abutments of local limestone, the roadway, as in the case of the Baran Bridge, being made of ferro-concrete slabs.

From this point the road passes over a cultivated plain through an avenue of tamarisks to Miranshah Militia Post, the headquarters of the Northern Waziristan Militia.

It was always a refreshing sight to see the Union Jack flying above the mud brick parapets, even though it was hung upside down.

Such is a brief description of the country in which this frontier road was made. It will be seen that there were no real engineering difficulties to be met. What difficulties there were were of another kind. Want of labour was the chief. There was no local labour worth mentioning. The people who inhabit this part of the valley are too much occupied in agriculture to care about taking contracts for roadmaking. By far the best workers in this part of the world are the people wrongly called Mahsuds (it should be Mahsid). In 1917, when the reconstruction was started, they were under a blockade which developed later in the year to a small expedition. When this was over, Mahsud contractors swarmed in to Bannu seeking contracts for excavating work, and many such contracts were given out. This people cannot work in the valleys in hot weather, so the Mahsud season only lasts from about October till April.

In the autumn of 1917 a Labour Corps was sent to the valley, and is probably there till this day.

All masonry work was done by Mahommedan contractors from

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Peshawar and Nowshera; Hindus were afraid to work in the valley owing to the risk of being killed or carried off by outlaws. As there was no competition, much higher prices had to be given then those prevalent in India.

A further cause of trouble was the chronic state of danger caused by outlaws and raiders who resided in the district of Afghanistan called Khost, 40 miles away to the north, and treated the Tochi Valley as a happy hunting ground.

Previous to the Afghan War the road was picketted for six hours daily by men from the Militia Posts and blockhouses along the road, no traffic being allowed outside these hours. Working parties were accompanied by guards (*badraggas*) taken from the local Wazirs. Whenever an important bridge was made, a blockhouse had first to be built near the site to protect the stores collected there and workmen who lived alongside it.

There was always considerable delay in obtaining stores from down country, local material was of course used as far as possible, but such things as steel girders, pumps, cement, steam-rollers, water-carts, took many months to collect. When work was started there were only three large steam-rollers available at Bannu, and it took two and a half years to bring the total up to 19.

One of the minor difficulties was the constant stream of traffic along the road during the six hours it was open. The garrison of Miranshah consisting as it did of two battalions and other smaller bodies of troops, required, to feed it, a convoy three miles long consisting mostly of camels, once every ten days. The convoy took three days to go and three days to return, so there were only four days in ten during which the road was comparatively free.

In addition to convoys there were always tongas on the road and numerous small caravans of frontier tribesmen carrying timber down the Tochi to sell at Bannu.

Below I give a few details regarding methods of construction and materials used.

The hard blue limestone boulders which abound in most of the nullahs were used as material for soling, if none was procurable nearer, and when broken up, for road metal. Where nullahs were too far away the nearest outcrop of good limestone was quarried for road metal. All stone was broken by hand. I found that stone breaking was something of an art, as an unskilled Labour Corps man could not break half as much as an experienced Pathan in the same time.

Culverts varied in waterway from 2 to 15 ft., the width depends not only on the water expected but on the amount of mud and stones which, falling from the hillside above, have to be carried under the road. For this reason elaborate calculations for waterway based on expected rainfall are a waste of time. It was found by

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experience that in the case of larger culverts a basis of 20 ft. of waterway for a square mile of collecting area was satisfactory. It was often cheaper and just as good to make culverts in two short spans instead of one larger one. The floors of culverts were generally paved to save depth of foundation, and were sloped as much as possible. The foundations of culverts were usually made of lime concrete. The walls were of masonry 18 in. thick in lime mortar. The tops were usually of ferro-concrete slabs for short spans with a 6-in. layer of earth between the slab and the soling. For longer spans (5 ft. and over) old rails or girders were used, with jack arches of lime cement concrete or with ferro-concrete slabs. The roadway was 20 ft. wide. The parapets were 18 in. high with a cement concrete coping on top about 4 in. thick.

Corrugated iron had been used in a lot of the old culverts, most of it had perished through the action of saltpetre, with which the soil is impregnated.

Stone for building culverts and bridges was quarried in the nearest limestone outcrop, but in the section between Saidgi and Khajuri it was obtained from huge limestone boulders, which were found in the river bed. These boulders had originally been embedded like currants in a cake in the clay formation already referred to as being conspicuous at Shinkai.

Lime was burnt at convenient places along the road, it was slightly hydraulic, and specimens from old culverts showed that it got very hard in the course of years. Sand was always easily obtainable.

The possibility of narrowing a nullah had formed an interesting study in connection with the bridging of it. As already pointed out, the appearance of a nullah bed on the frontier is apt to give an entirely erroneous impression of the quantity of water which comes down it during a flood, especially when the banks are vague and ill-defined.

In nearly every case calculations were made to ascertain the waterway required, by noting high flood marks, taking the fall of the river bed and sections at various points and applying Nutter's or Manning's formula. The waterway having been decided on and the velocity found, the probable scour was obtained by an adaptation of Kennedy's well-known formula for standard silt. The results appeared to be satisfactory.

In the case of the four bridges in which old railway girders were used, the girder erection was carried out by a gang from the North Western Railway, the abutments and piers having been built by contract.

The wing walls of bridges and also of culverts received a good deal of attention; I have seen many cases of bridges in which the wing walls fail to properly contain the whole width of road, owing to the

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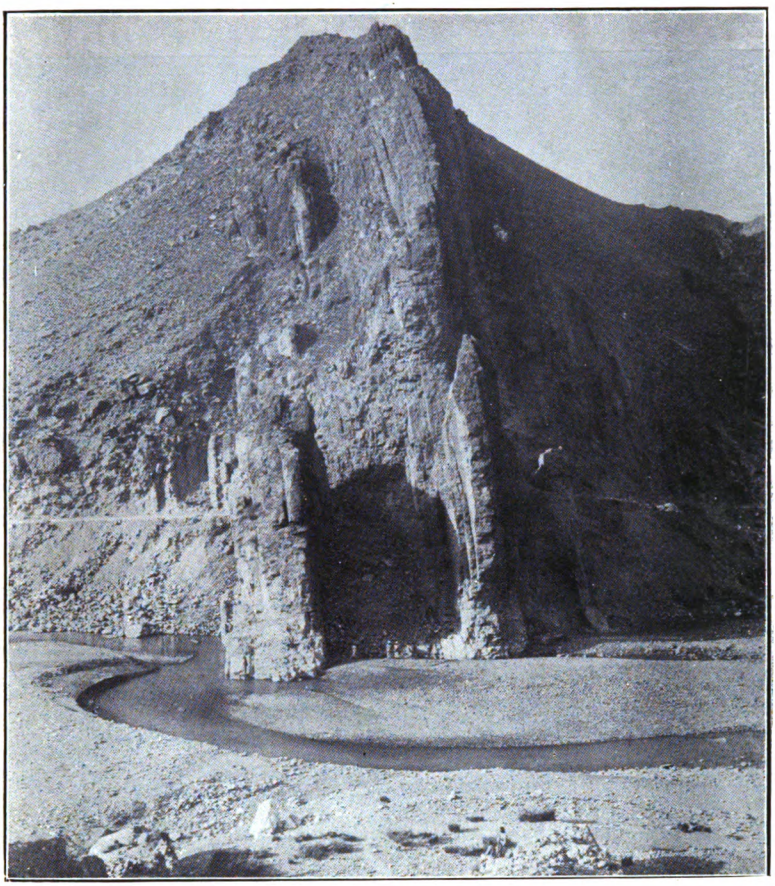
A FRONTIER MOTOR ROAD.



Site of Lower Shinkai Bridge.

Lower Shinkai Bridge.

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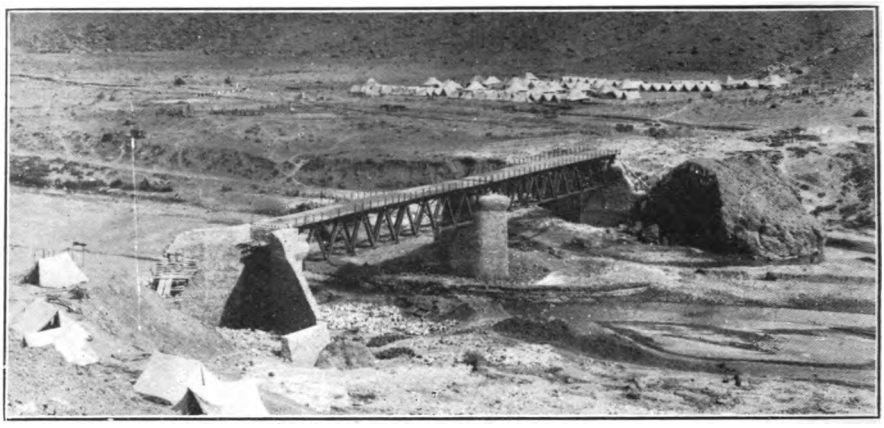
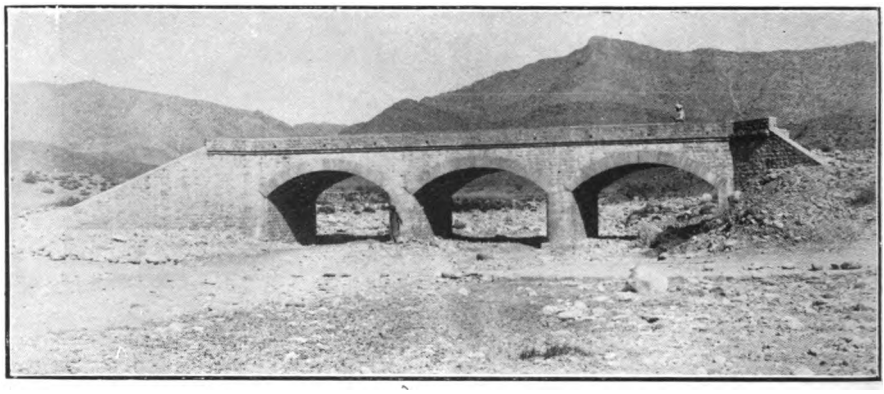
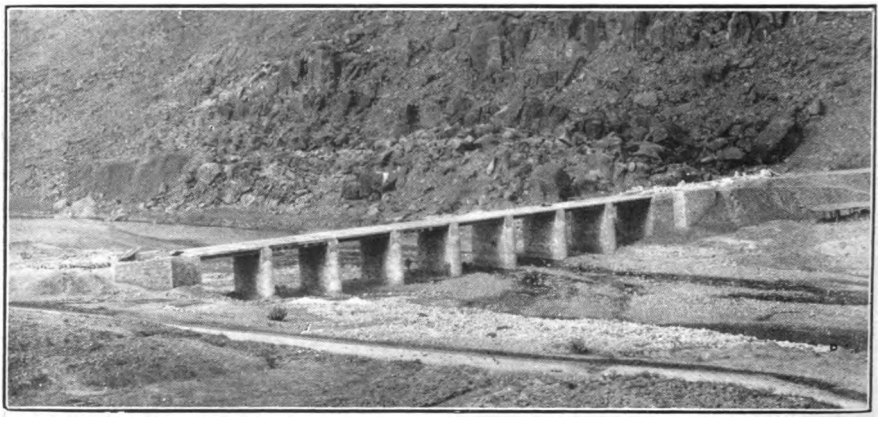


Upper Shinkai Bridge.



Lorisa Bridge.



Khajuri Bridge.

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walls being built of insufficient height to admit of the bank standing at its natural slope.

Before the Afghan War the road between Miranshah and Datta Khel was being made fit for mechanical transport, and considerable progress had been made with the first ten miles. But the valley beyond Miranshah has been entirely abandoned for the present, and until it is again occupied and protected there will be no possibility of continuing the work.

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ENGINEER SERVICES WITH THE NORTH RUSSIA E.F., ARCHANGEL.

Extracts from a Report by Lt.-Col. G. B. HULL, O.B.E., R.E., C.R.E. Base and Local Forces.

WHEN the British Forces occupied Archangel in the late summer of 1918, and the Bolsheviks withdrew to positions up the river Dwina and along the Vologda Railway, the outstanding demands for Engineer work were for the reconstruction of destroyed bridges, accommodation for Infantry, R.A.S.C., R.A.O.C., R.A.F., at base, on the L. of C. and at the fronts, defences, and the maintenance of the existing municipal services in Archangel, such as water supply, lighting, and tramways.

Practically nothing in the way of stores for Engineer work was brought to Archangel with the Force, and recourse was made to the stocks of general building stores held in Archangel, chiefly at the Customs House and Port Depôt, for war and general purposes.

An examination of these stores showed that they would be insufficient to meet the demands for Engineer work and that they would have to be supplemented by stores from home. Indents for a six months' supply of stores likely to be required were, therefore, prepared and dispatched to London, and it was hoped that some of this material would be delivered in Archangel before the port froze. Large stocks of sawn timber of all sizes were immediately available locally, and it was possible to send early supplies to the river and railway fronts for use there.

The Engineer personnel available for work at that time consisted chiefly of the 310th Battalion U.S. Engineers. One company was kept in Archangel working on barrack construction, operating a saw-mill, and doing general Engineer work at the base, and the remaining companies were sent to the front for forward work, defences and accommodation, etc., the work there being controlled by R.E. officers. The British Engineer personnel was very limited in number and was used for the most part in supervising Russian civilian labour which at that time was largely used.

Much of the base work, such as hospitals and hangars, was given out to contractors, and some was carried out by civil labour administered and controlled by R.E.

One of the factors in the efficient administration of civil labour was

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the devising of a suitable rationing scheme. The civilians in general were rationed by the civil authorities and received a meagre ration, but workmen employed by the military authorities on essential services, received an " essential service " ration card with which they could purchase additional foodstuffs from R.A.S.C. depôts, the value of the ration being deducted from the amount due as wages. In the case of men temporarily employed a " bonus ration card " was issued which enabled them to purchase a limited amount of food from military sources.

Until supplies were received from England considerable quantities of stores and material of all kinds were obtained from the Custom House and from the port authorities. In the case of stores held in the Custom House, the Governor General was requested to authorize the requisition of the particular articles required. No direct payment was made, but an account was kept of the transaction for later settlement between the two Governments through the Claims Commission eventually instituted for this purpose. The stores requisitioned through this service consisted of nails, sheet-iron, plain wire, paint and oils, axes, cordage, oil engines, etc. Stores of a different class, such as manufactured iron work, etc., were obtained from the port. In this case application was made direct to the port authorities to furnish or manufacture the article required and the account was referred to Claims Commission for later settlement.

Considerable quantities of sawn timber were acquired locally. A naval officer was acting as representative of the Timber Controller, and purchased timber for home use on a large scale. He was frequently able to hand over small lots of this Government timber to the R.E. for local military purposes. In other cases timber was purchased direct from the mill-owner and paid for in cash on a sterling basis, and details of such transactions, quantity and price, were always given to the Timber Controller, at his request, before the transaction was completed.

In addition to these two sources of timber supply, the output from a mill owned and operated by the port authorities at Bakharitza was used entirely for military work ; no direct payment being made for the timber supplied. Most of this timber was used at Bakharitza, which lies on the opposite side of the river from Archangel, or sent from there up the railway to the front. Timber required in Archangel itself, was sawn by the U.S. Engineer personnel at a local mill from logs purchased from the Northern Railway. The logs were found stacked for sawing at this particular mill, and an arrangement was made with the mill owner for use of the machinery, etc., to do the work.

In order to strengthen the Engineer personnel available for work, civilian tradesmen who enlisted in the Slavo-British Legion were drafted into a unit known as No. 1 Engineer Training Company.

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Not more than 30 or 40 recruits were obtained, however, though these performed very useful work throughout the whole period of the unit's existence. Later, an establishment was approved for this company, and it became the 383 E.T. Company.

Other companies R.E. formed at this time were the 381 Works Co., R.E., and the 382 E. and M. Co., R.E. Both were considerably below the normal strength of such companies, but it was hoped that reinforcements would bring them to a strength more in keeping with the work there was for them to do. In spite of low strength both companies later on did remarkably good work; the Works Company supervised and administered most of the extensive work in Archangel, and the E. and M. Company, besides the shop work at base, installed lighting sets and searchlight sets at base, on the L. of C. and at Force headquarters, and maintained the lighting over a very large area.

The maintenance of the existing municipal services was of great importance and demanded special attention. A *liaison* officer for municipal services was appointed for this work, and he and his staff kept in close touch with the heads of the various municipal departments controlling water supply, lighting, tramways, roads, etc. It was his duty to make himself acquainted with methods of operation and maintenance, and to furnish the municipality with any essential supplies, not locally procurable, required for the upkeep of these services, as well as to arrange for rations and exemptions from military service for essential employees, and to provide tram transport for military supplies as required. In this connection tramway extensions were laid to hospitals and R.A.S.C. main depôt; and in order to provide fuel for winter use by the troops in Archangel, an extension four miles long was laid to an up-river saw mill and fire wood in very large quantities delivered over this line to the R.A.S.C. distributing centre in Archangel.

In the autumn of 1918 arrangements were completed for the formation of Russian Engineer units on the same lines as R.E. Field Companies. These units were designed to take over, eventually, the Engineer work with the Russian army then about to be formed. Two companies of 1 H.Q. section and four other sections were formed. They were commanded by an English-speaking Russian Engineer officer of considerable experience and were, of course, administered by the Russians, but trained along British lines by British instructors. An experienced Russian-speaking British officer was appointed as *liaison* officer, and the training was arranged and supervised by him. These companies eventually proved very useful, and one company in particular did remarkably good work on the railway front during a critical and trying period. At a later date, a Russian Engineer Works Company was formed to take over the work which was being done by the 381 Works Company R.E.

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The map shows the areas occupied by the Forces during autumn and winter, and the disposition of the R.E. personnel.

The R.E. work at the fronts during the autumn consisted chiefly of building and fitting up accommodation for troops, including hospital accommodation, general sanitation, defence works of all kinds, including block houses, M.G. positions, wiring, etc., and preparation for coming winter conditions. On the railway front very little existing accommodation was available, the villages being very few, small, and far between. Box-cars were lined with match boarding, fitted with stoves, bunked for 16 to 18 men, and so converted into very suitable quarters, which possessed the advantage of being movable. On the river front, villages were close together and afforded, in general, adequate accommodation; though the houses taken over had to be fitted with bunks and sanitary arrangements.

No standard type of block-house was adopted, as circumstances and conditions varied in different localities. Except along the railway itself the most general type on the Vologda front was one built of logs in walls 4 ft. thick, giving a space of 15 ft. by 15 ft. inside. The logs used were 23 ft. long and about 6 in. thick, heavier logs being too inconvenient to handle. When the walls had been brought up 2 ft. above floor level the log floor was laid, covered to a depth of 2 in. with moss, and then covered with the true floor of 2-in. planking. The walls are strengthened with upright poles wired together at corners and entrance, the spaces between logs being well filled with moss and earth. The Russian workmen are particularly good at this type of construction.

At a height of 4 ft. 6 in. above the floor a loophole or slit, 6 in. high inside and 10 in. outside, is left for almost the full length of the wall, and is covered with a hinged board fitted with two small windows. The flaps can be swung open immediately any action commences. The roof is sloping and is made of a layer of splinter-proof logs, covered with 2-in. planking and finished with roofing felt. The house is fitted with a stove and bunked for eight men. This type of block-house, with solid log walls, was evolved for use in forest country where the difficulties of transporting sand for filling between single walls, were abnormal. With the long slits provided, all-round fire can be obtained, and the fact that they are difficult to conceal is unimportant in forest country, compared with the advantages of wide field of view and of fire, and of the strength of fire which can be brought to bear in any required direction. The tactical strength is greatly improved by lanes cut through the trees, and wired, enabling block-houses to be grouped into defended localities so that adjacent block-houses are mutually supporting against attack from any direction.

On the river front, where sand is usually available, the most general type of block-house was one consisting of two single log walls

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with 3 ft. of sand between. The outer log walls are 6 ft. high only, and the loopholes are built into sand bags laid on the sand filling. A splinter-proof log ceiling is covered with sand and a double slope roof built above this. Entrance is afforded from a trench leading to a trap door in the floor.

Modifications of the above types were often built when local conditions and requirements demanded. Provided the block-house has the essentials of good loopholes, bullet and splinter-proof walls and roof, and is as low as is consistent with sufficient head room above loop holes, there is little need for rigid adherence to a particular type It is the siting of the block-house which calls for most skill and good judgment, the appraisement of the topographical features of the country and the likelihood of the direction of attack.

Machine-gun emplacements were of the type evolved by experience in France, but were log constructed, one-way or three-way as required.

Knife-rest or double-apron wiring was generally used. A special W.R.E.F. pattern, double-apron fence was evolved during the winter which required no pickets, was built on the snow and which sank as the snow melted and remained rigid and upright when it rested on the natural ground.

Special efforts were made in the autumn to forward adequate supplies of stores for Engineer purposes, sawn timber, etc., for the front before the river froze. All departments were equally desirous of doing this, and although only a limited number of barges were available, a considerable quantity of barbed and plain wire, nails, timber, glass, roofing felt, sandbags, explosives, felling axes, tools, heating stoves, etc., were delivered at various centres on the river front, and good stocks were, therefore, available by the time winter set in. Lighting sets had been installed at troop centres along the L. of C. and at Force H.Qs., and the necessary wiring to offices, hospitals etc., completed, before the beginning of winter.

The information furnished locally concerning the winter conditions which could be expected, showed that the depth of snow in the open varied between 3 and 7 feet; and that temperatures averaging 20 degrees below zero F. could be expected over lengthy periods; and block houses were built with these depths of snow in view. The actual conditions varied considerably from the anticipated, and records of snow depths kept by Engineer officers showed that the depth in open country varied between 10 and 30 inches, and block houses proved in many cases to give a higher command than was generally desirable. Minimum temperature in January, February and March varied from 18 degrees to 36 degrees below zero F. though lower temperatures were recorded for short spells. Contrary to expectation based on popular reports, the temperature did not average 20 degrees below zero for any cold spell of three days or more during the whole winter.

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When winter set in and the river froze, all stores and supplies, except those for the railway front, had to be sent by sleigh, and the maintenance of the L. of C. became a most important feature of winter R.E. work, as it involved work over a total line of about 700 miles.

It was necessary to provide rest houses with accommodation for officers and men at each stage of approximately 20 miles, along sleigh routes. In most cases, village houses were taken over and completed with bunks and sanitary arrangements for this purpose. In one case, however, a large log-house had to be constructed in the forest, remote from the nearest village. The house was built by about 30 Russian axe-men in charge of a R.E. corporal, and rations and supplies were sent by sleigh to the party from a depôt 60 miles away. It provided sleeping, cooking and heating accommodation for 60 men and 12 officers, and its construction gives an idea of R.E. administration on the L. of C. with the very limited R.E. personnel available. The N.C.O. spoke no Russian and had no interpreter.

Only 4 R.E. officers were employed on the River L. of C., each administered, as D.O., R.E., an area averaging about 70 miles long, and was responsible for rest houses, sanitation, defences, repair and maintenance of bridges, buildings and fittings for R.A.O.C. and R.A.S.C. stores, Y.M.C.A., hospitals, etc. Each officer usually had a N.C.O. to assist him and the work was done by civilians, in some cases by contract, and in others by direct administration. Stoves and sheet iron work for sanitary purposes were also made on the L. of C. The lighting was installed and maintained separately by the E. and M. Co. with a R.E. N.C.O. or sapper in charge of the set at each place, and very few cases of breakdown occurred.

The winter roads are carried over numerous ravines by wooden bridges, all of which were examined by a R.E. officer and, where necessary, repaired and strengthened to carry guns.

The R.E. work on the L. of C. was in general administered and inspected by an O.C. R.E. under the C.R.E. An inspection of the river L. of C. necessitated three weeks steady travel by sleigh.

During the winter a review of the stores situation was made, and indents on London prepared for a six months' period from June, 1919, on the assumption that an offensive would begin when the river became navigable and reinforcements arrived. At no time during the winter was there any serious shortage of stores for Engineer work at the Front, those that had been sent up before the river froze, with limited additional supplies sent up by sleigh during the winter, proving just about sufficient to meet the demands. Any special workshop article required was made in workshops at the Base and could be delivered to a point 200 miles up river in three to four days.

In order to be prepared for a possible advance along the railway in the spring, a timber trestle bridge was prepared at the base ready to

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replace the Emptsa bridge, a structure of considerable size, which had been demolished by the enemy in his retirement from Obozerskaya. The enemy occupied a position on our side of the bridge, and direct access to it for examination was not, therefore, possible. The railway plans of this bridge as it stood before destruction gave length and height, and drawings were prepared with this information. The bridge members were constructed by a party of U.S. Engineers working under the R.E. officer responsible for the design and construction of the bridge, and were assembled, marked, dismantled and loaded into trucks complete with bolts and fittings, ready to be sent forward to the site as soon as the enemy was dislodged.

The work at the front during the winter consisted largely in elaborating and extending defence works, etc. commenced in the autumn; constructing new defence systems, clearing forests for fields of fire from block-houses, wiring, etc.; and in general Engineer work. Villages were usually encircled by mutually supporting block-houses, numerous carefully sited M.G. emplacements included in each system and the whole wired with knife-rest and double-apron wire. Existing houses in forward villages were frequently sand-bagged and converted into block-houses.

The Engineer work with each force was controlled and administered by an O.C. R.E. attached to Force H.Q. and having under him several officers as D.O. R.E. in charge of defence and other work at the front. The long sleigh journeys involved made frequent inspection by the C.R.E. an impossibility, and the appointment of an O.C. R.E. having ample discretionary powers in the administering of the large area, to represent him with the Force, was essential. The officers of the 310th U.S. Engineers lent at all times admirable support, and the U.S. Engineer sections employed on the different fronts did uniformly excellent work. As far as possible civil labour was used, and work in the rear of the front line was largely done by peasants supervised by Engineer officers or N.C.O.'s. The system had its drawbacks as it was comparatively simple for any pro-enemy person to cross the line with useful information. But the circumstances demanded that as much use as possible was made of civilians.

The long lines of communication and the limited number of troops available for guarding them, enabled the enemy to attack, and in one or two cases, to occupy villages on the L. of C., so constituting a threat to Archangel, as well as temporarily cutting off supplies from the base to the Force. Such attacks made rapid construction of defences essential, and all available forces were concentrated on the particular locality to be defended, until the work was completed.

The occupation of Bolshe-Ozerki by the enemy during the winter led to the construction of a rear line of defences some 10 to 15 miles south of Archangel. The line was about 20 miles long and consisted

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of solid log block-houses about half a mile apart, with M.G. positions, wire and many acres of clearing for fields of fire. When the system was nearly completed, the enemy was dislodged from Bolshe-Ozerki and the work suspended. Later, in the summer, when the mutiny at Checuevo and Onega gave that and additional territory again into enemy hands, the line was completed and extended to Kenetzbor on the sea coast to the W. of Archangel.

The approach of the winter was marked by a general softening and breaking up of the sleigh roads, and the transportation of supplies to the front became increasingly difficult. Local information indicated that there would be a period of two to three weeks when the ice was breaking up in the river and the snow roads had disappeared, when the forces would be completely cut off, as it would not be possible for supplies to be delivered either by road or river. It was thought that this might prove a critical period as the clear water in the upper reaches of the river would enable the enemy to attack our villages on the river banks with gun boats. Special efforts were therefore, made during the last few weeks preceding the thaw, to add as much as possible to the then rather low stocks held in dumps near the front, and although the ponies were wearing out and sleigh transport strained to the utmost and in spite of the urgency for ammunition and food, sufficient Engineer stores were delivered to carry the forces over the difficult period and to provide for the hasty construction of defences in case of need.

Towards the end of the winter preparations were made for accommodation in Archangel and district, for the Relief Force expected to arrive in May; and as the Russian Army had considerably increased in size and required much of the accommodation already available, much new barrack work for British troops was required and completed. The mobilization of the Russian civilians had produced a dearth of labour which was general over the whole area occupied by us, and construction work at this time was done under considerable difficulty. In addition to barracks, etc., provision had to be made for storing the large quantities of stores, ordered for the offensive, which were expected to arrive when navigation was resumed. This entailed the construction of eight or nine additional transit and store sheds 200 ft. long by 70 ft. wide, at Bakharitza.

Many thousands of duckboards were made at Base R.E. shops for use at troop centres near the front to facilitate transit over the swampy ground in spring; and sufficient quantities of tent-bottoms for bell and hospital tents, were made to accommodate the British and Russian reinforcements for the forces.

On May 26th, 1919 the first Brigade of the Relief Force arrived, and the second Brigade arrived shortly afterwards. The two Field Cos. were sent to the river front within a few days of their landing and relieved the U.S. Engineers, who returned to base

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and prepared for their departure to U.S. They left in June after a year of valuable service with the Force. In addition to defence and general work, the U.S. Engineers had, in the absence of a mapping section, taken over the work of surveying, mapping, and map production for the entire force, and produced maps of several hundreds of square miles of territory. Most of the surveying was done in the winter, sometimes in temperatures as low as 30 degrees to 40 degrees below zero. The survey information was compiled at G.H.Q., maps made, lithographed, and sent to the Intelligence Dept. for distribution.

By this time the two companies of Russian Engineers had completed their training and were ready for work. The first company was sent to the river front and the second to the railway front, each under its Russian officers assisted by a British Engineer *liaison* officer. The time and energy put into this formation and training bore its fruit, and both companies did very creditable work; and during the mutinous period which developed later among the Russians, they remained loyal, although subjected to the same pernicious mutinous influence which undermined other Russian regiments.

During the formation and training of "Dyer's" and "Burke's" battalions, it was felt that a Russian platoon from each battalion, would do much towards meeting the requirements of the battalion for Engineer services. The proposal received sanction from G.H.Q. and about 60 suitable tradesmen were therefore detached from the infantry and formed into a pioneer platoon. The men were put to work under an Engineer officer and trained in barrack erection and general defence work. They performed very useful work both before and after the mutiny of "Dyer's" battalion.

As soon as the ice had gone and navigation was resumed, the stores indented for during the winter began to arrive from England in large quantities. Barge loads of Engineer stores, such as C.G.I., roofing felt, water pipes, dogs and spikes, etc., as well as stores of ordnance supply, as barbed wire, sandbags, nails, shop iron, etc., were prepared by the Chief Stores Officer R.E. for dispatch to the river front and sent as early as possible to stock the R.E. Advanced Park which was established at Bereznik upon the opening of the river. The water in the river fell rapidly after the first thaw flood and navigation became increasingly difficult with the heavy draught tugs available. In spite of low water, however, several barges of Engineer stores and material, as well as timber barges, were delivered at the park, and by the time the plans for the advance on Kotlas were completed, the park had ample stocks.

The change in policy from winter defence to summer offence to join with Koltchak at Kotlas, led to G.H.Q. moving from Archangel to Bereznik, and necessitated a reorganization of R.E

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administration. Appended are two charts which showed R.E. organization before and after the move of G.H.Q.

The unusually low water and the scarcity of light draught tugs made the question of getting supplies up the higher reaches of the river towards Kotlas, a difficult one. A few self-propelled light draught barges were available, and one of these was secured for Engineer purposes and was loaded with carefully selected stores and material from the advanced R.E. park as a supply barge for the Field Cos. It was intended that this barge should follow up the R.E. in the advance, and that stores required for offensive purposes, etc. should be issued from it.

The forward work on the river front at this period included the construction of several landing stages and piers. These were built of log trestles with sawn timber superstructure. Also corduroy roads, laid to facilitate the transportation of stores from the river to dumps; as well as accommodation and general work.

The uncertain situation on the Pinega River, about 100 miles in the rear of the Dwina front, led to the transferring of certain British troops to Usb-pinega, to check enemy raids in that neighbourhood, and one Field Co. was withdrawn to that point for the construction of defensive and other works there.

About this time mutiny amongst Russian troops gave Checuevo and Onega into the hands of the enemy. From Checuevo he was able to threaten the railway near Obozerskaya, and from Onega he marched along the coast road towards Archangel. This necessitated the completion and extension of the defence line about 10 miles south of Archangel which had been commenced and partially completed during the winter. Small parties of R.E. were sent to Lyavla, Metchka, V. 581 on the railway and to Konetsboz. The whole line was reconnoitred, paths leading to block-houses, etc. cut and marked by sign boards, block-houses and M.G. positions completed where necessary and clearing done for fields of fire. In addition to this, local defences were constructed on the road between Obozerskaya and Checuevo, as well as at points along the railway between Obozerskaya and Archangel, a section of Field Co. engineers being sent up for that purpose.

When Admiral Koltchak's advance on Viatka was checked, and he retired to positions east of Perm, our own plan of advancing to Kotlas to meet him was abandoned and G.H.Q. returned to Archangel.

The railway front was held, at this time, entirely by Russian troops with a few British Engineers, Artillery, and Technical units in support, and enemy agents in the ranks of the Russian troops had organized a mutiny on the front beyond Obozerskaya and on the left flank near Seletskoe. The right flank at Checuevo had already become Bolshevik; and although, this time, the enemy intentions

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were frustrated, the general uncertainty as to the behaviour of the Russian troops led to the preparation of schemes for demolitions along the railway in case the line broke and the Bolsheviks advanced. The plans included the burning of timber bridges, and the demolition of iron bridges, earth embankments, water towers, etc. The mutinous period passed, however, and no demolitions proved to be necessary. The Russian Engineers employed on the railway front worked loyally with the British and performed very useful work, especially in connection with the constant repairs to the track, which were made necessary by enemy action.

When the decision to evacuate was finally announced, arrangements were completed for the removal to Base of stores held at the advance R.E. park. Such stores as were urgently needed by the Murmansk force were sent to Murmansk, and part of the saleable stores shipped to England.

To enable rear-guard actions to be fought in case of necessity during our withdrawal down the river, piers and landing stages, sufficiently strong to carry 18-pounder guns, were constructed at some twenty places between Bereznik and Archangel. This work was done chiefly by local contractors under the supervision of the O.C. R.E. L. of C. By this time, August, the river was on the rise and navigation and the movement of troops, etc. became less difficult.

When the N. Russian Government decided to continue operations against the Bolsheviks after the evacuation of the British the existing stocks of R.E. stores and material, sawn timber, etc. were handed over to the Russians.

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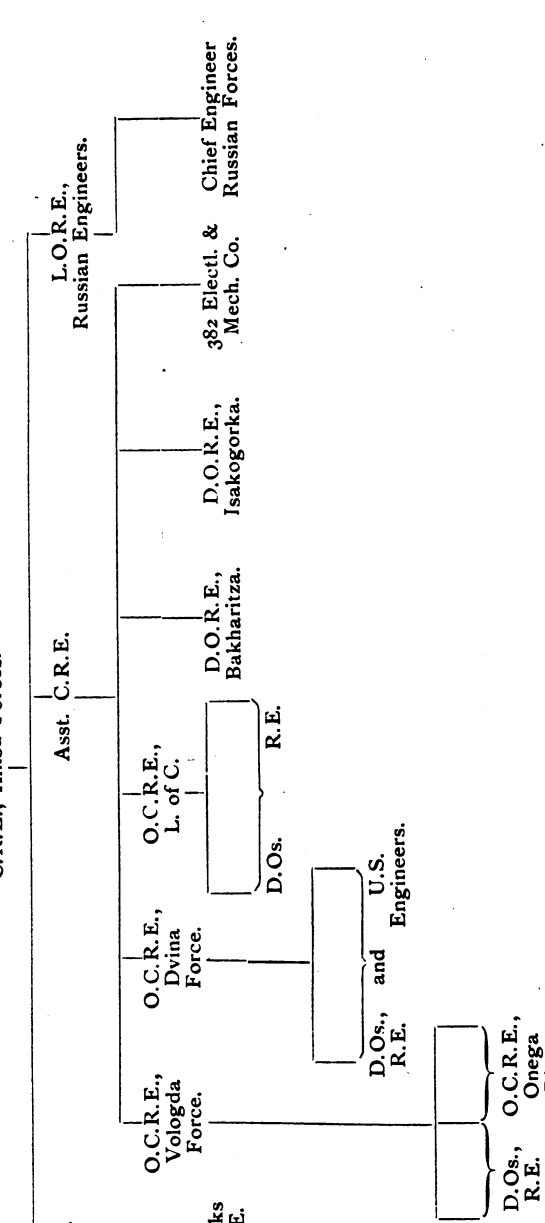
R.E. ORGANIZATION CHART.

BEFORE MOVE OF G.H.Q.



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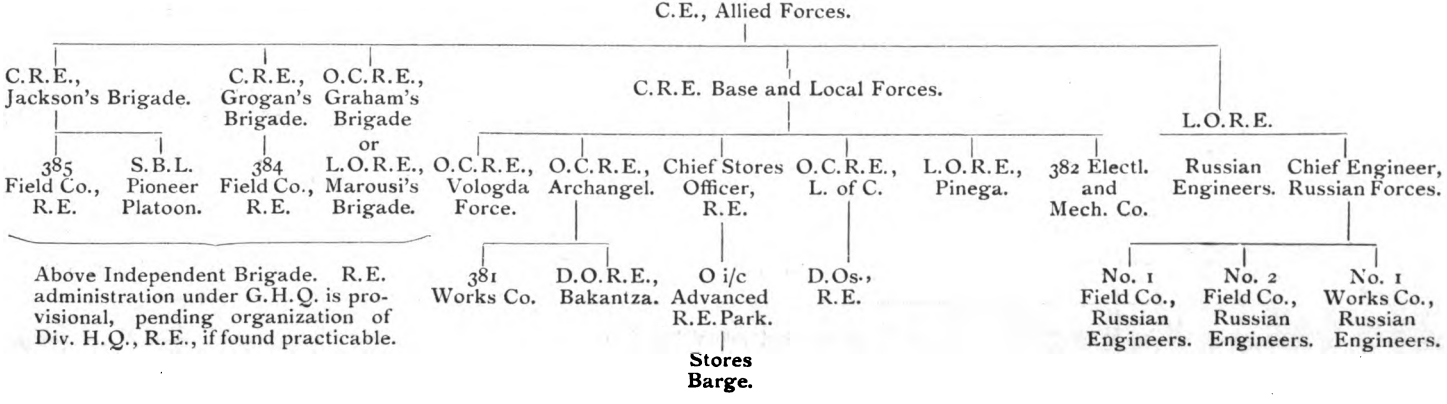
R.E. ORGANIZATION CHART.

AFTER MOVE OF G.H.Q.


C.E., Allied Forces.
C.R.E., Jackson's Brigade.
C.R.E., Grogan's Brigade.
O.C.R.E., Graham's Brigade or L.O.R.E., Marousi's Brigade.
C.R.E. Base and Local Forces.
L.O.R.E.
385 Field Co., R.E.
S.B.L. Pioneer Platoon.
384 Field Co., R.E.
O.C.R.E., Vologda Force.
O.C.R.E., Archangel.
Chief Stores Officer, R.E.
O.C.R.E., L. of C.
L.O.R.E., Pinega.
382 Electl. and Mech. Co.
Russian Engineers.
Chief Engineer, Russian Forces.
Above Independent Brigade. R.E. administration under G.H.Q. is provisional, pending organization of Div. H.Q., R.E., if found practicable.
381 Works Co.
D.O.R.E., Bakantza.
O i/c Advanced R.E. Park.
D.Os., R.E.
Stores Barge.
No. 1 Field Co., Russian Engineers.
No. 2 Field Co., Russian Engineers.
No. 1 Works Co., Russian Engineers.

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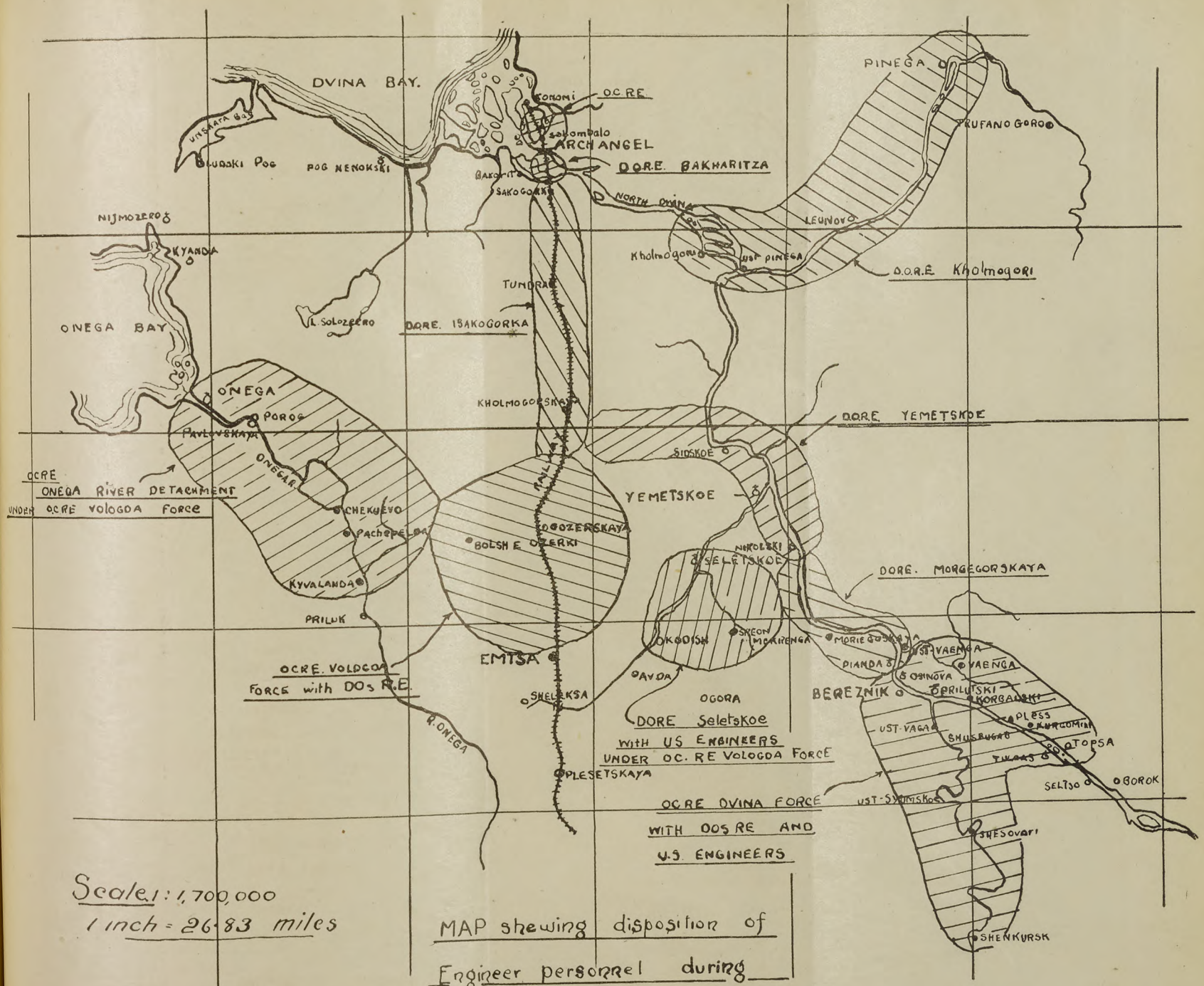

Scale 1 : 1,700,000
1 inch = 26·83 miles

MAP shewing disposition of Engineer personnel during winter.

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THE EVOLUTION OF FIELD FORTIFICATION DURING THE LATE WAR.

From an article by Capitaine Botte, published in the May-June number of the Revue Militaire Générale. By Colonel A. R. REYNOLDS.

THE Author commences with a sketch of the principles ruling before the war, and shows how these were modified by instructions issued in December, 1915, again in August, 1917, and lastly by the decisive events of 1918.

The pre-war principles were enunciated in a general and rather inconclusive manner in the F.S. Regulations of December, 1913, article 146 of which states, " Positions to be defended, centres of resistance and supporting points to be occupied, will be decided upon by the commander in accordance with the object to be attained. The organization of a supporting point will be regulated by the officer appointed to its command." The infantry should have a clear field of fire up to medium ranges (800 to 1,000 metres), invisibility is to be studied, and the construction of dummy trenches is recommended, while the occupation of the edges of localities and woods exposed to enemy artillery fire is deprecated, and, although this is not distinctly stated, it is evidently intended that reinforcements should be under cover close to the firing line. Chapter IV of the same regulations says that " a centre of resistance may comprise one important or several neighbouring supporting points." The idea then held of a supporting point will be shown later. Mutual flanking from supporting points is enjoined.

This is all that the infantry officer could find in the regulations for his arm in regard to the organization of the ground he had to defend. A course of field fortification was part of the curriculum of every military school, but in view of the unpopularity of the defence courage was required to follow it attentively. Engineer officers received fuller and more precise instructions. In the *Aide-Mémoire de l'Officier du Génie*, after an enumeration of the conditions to be satisfied, amongst which will be noted a field of fire of 200 to 300 yards only, a general description is given of a fortified position. The principal position will generally consist of two lines, one for infantry, the other for artillery, the former 500 to 600 metres in front of the latter, so that the guns would be secure from enemy infantry fire and be left free to develop their own fire. The main infantry line of defence will be marked by supporting points, each

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consisting either of a group of works made entirely with the spade (*retrenchements élevés de toutes pièces*) or of a locality or wood placed in a state of defence. Machine-guns will be used to flank the intervals. The choice of sites for the supporting points must depend on the lie of the ground, but for mutual support they must not be more than 1,200 metres apart. The long distance between supporting points should be noted.

The "supporting point consisting of a group of works made entirely with the spade" was intended to hold one or two companies according to its importance, and was to consist of trenches of full or half section linked up by communication trenches to a closed work in rear constituting the keep. In short, it may be deduced from the pre-war regulations that the main position of defence was to consist of a series of strong points called "centres of resistance," or "supporting points" according to their importance, and that these strong points were to be separated by intervals of about a kilometre, access to which was interdicted by flanking fire from the strong points; in other words, a series of bastions flanking imaginary curtains, since the strong points were not interconnected. This disposition facilitated command, the strong point was crammed with defenders all under the eye of their commander, and was intended to economize troops, although it should be noted that one battalion per kilometre of defensive front was required. To-day, with very different principles, no more troops are required, and, if the number of automatic weapons has increased the appliances of the assailant have developed equally. It is interesting to note how much the organization of the position resembled that of a fortress.

As to organization in depth there was, first, the advanced position which would delay the enemy's march and give the defenders of the main position time to reach their stations; second, the main position on which the enemy would be brought to a standstill; and lastly, a second line intended finally to limit his progress. This organization somewhat resembled that of a fortress, but more nearly the dispositions laid down in the regulations for outposts, the advanced position corresponding to the sentry groups and sentries, the troops of the main position to the piquets, and the second line to the outpost reserves. The organization was logical, and it is interesting to note that, abandoned for the greater part of the war, it was again adopted in the summer of 1918.

Now as to the application of these principles. In the first battle in August, 1914, the infantry distributed itself over the ground by occupying with constituted units, company or battalion, points considered to be favourable for defence, such as well-defined ridges, woods, farms, villages, *i.e.*, supporting points separated from each other by about a kilometre. Generally speaking these points were

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only occupied, and not prepared for defence, since all ranks thought too much of the offensive to have patience to dig trenches. Whether in consequence of aerial reconnaissance, or because the enemy divined these methods, the result was that a systematic artillery fire burst over the particular localities in which the troops were massed, and not only this, but the great distance between the supporting points entailed their fall by enabling them to be surrounded. Such are the deductions to be drawn from the battles of the end of August, 1914, and the problem to be solved—how to camouflage the occupation of a position—required no less than three years to solve.

After the battle of the Marne the occupation of a position assumed a new form. At first the assaulting waves established themselves elbow to elbow in sections of trench; the first days were passed on the watch behind the parapet in hopes of a resumption of the offensive, the most optimistic holding that the enemy would never remain stationary in this way, and that one day he would decamp. After some days of waiting, during which the troops were tired out, the necessity for organization became apparent, and from early in the stabilization period the continuous trench came into existence. Although not prescribed by regulation it was adopted everywhere, since it facilitated communication and supervision, the defenders felt themselves less isolated and no longer feared that their position might be turned. The long, thin, continuous line seemed to present great capacity for resistance; it possessed the advantage of impenetrability, it was difficult to damage, the destruction of 100 yards of trench calling for as great an expenditure of ammunition as that of a company supporting point, and if a section of trench was lost the gap could be quickly closed by the reserves stationed some 1,000 yards in rear. The disadvantages were that it required a very large force to hold, and being close to the enemy's line many lives were sacrificed from a pure spirit of emulation in holding a few yards of often unfavourable ground. The necessity for connection with the rear soon led to the construction of communication trenches, a work of such magnitude that at first some hesitation was shown in attempting it.

In January, 1915, a pamphlet entitled "Field Fortification in accordance with the First Lessons of the War" regulated certain details, but did not confirm or invalidate any of the general principles existing before the war. The writer states that he is unable to procure a copy of the pamphlet, and all that he remembers of it is the statement that two layers of round spars 15 cm. (6 in.) in diameter, separated by 30 cm. (1 ft.) of earth, was proof against the 150 mm. shell. The result was an acute crisis in the field parks which lasted the whole of the war, and raised against the engineers much ill-feeling which was no less lasting for being undeserved.

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Early in 1915 some armies doubled the first line by a support line, established a line to cover the artillery and prepared second positions. After the offensives of 9th May and 16th June two notes from G.H.Q. gave important directions drawn from their lessons. Admitting that the assailant could always capture the first line if he would face the necessary expenditure of ammunition to completely destroy the trench, it was considered indispensable to organize the defence in depth by establishing a second-first, or support line, about 200 yards in rear of the first. This could be strongly organized under the protection of the first line, might often escape observation from the ground, and at least the provision of artillery ammunition at that time did not admit in the ordinary way of the complete demolition of two lines; from it counter-attacks would start to re-capture lost portions of the first line. By this means less was to be feared if a sudden attack effected a breach in the first line, and from this time organization in depth continued to develop until the end of the war. The offensives of September, 1915, furnished further lessons, for instance, that in Champagne near Navarin Farm. Here the almost intact defences of a second position were met on a reverse slope, and the efficiency and surprise effect were experienced of machine-guns sited in the open, which later on induced a tendency to withdraw all vital weapons and other defensive appliances outside the network of entanglements and trenches.

All defensive organizations during 1915 were based on pre-war principles. After the linear organization at first imposed followed the constitution of a front formed of centres of resistance or supporting points (which expressions at that time had no precise signification), separated by intervals only passively defended. These strong points closely resembled the pre-war design and were referred to as "*fortins*" or "redoubts." The works showed up clearly on aerial photographs; in fact, the distribution of the troops was written on the ground, and the works being of small dimensions, with the vital weapons and other defensive appliances crowded together, could be destroyed by comparatively few rounds, and were regular "shell-traps."

The Instructions of December, 1915, imparted to all the idea of G.H.Q. on defensive organizations. The pre-war principles were modernized, and although centres of resistance were retained they were connected by continuous trenches, the centres or active zones always being separated by passive zones. On the sketch (copy attached) of a type centre of resistance was a note, which, apparently only of secondary, was of primary importance, and read, "It is essential, in order to disguise from the enemy the scheme of occupation of the position that the intervals should appear similar to the neighbouring supporting points," *i.e.*, that the centres should be connected together by communication or dummy trenches. From

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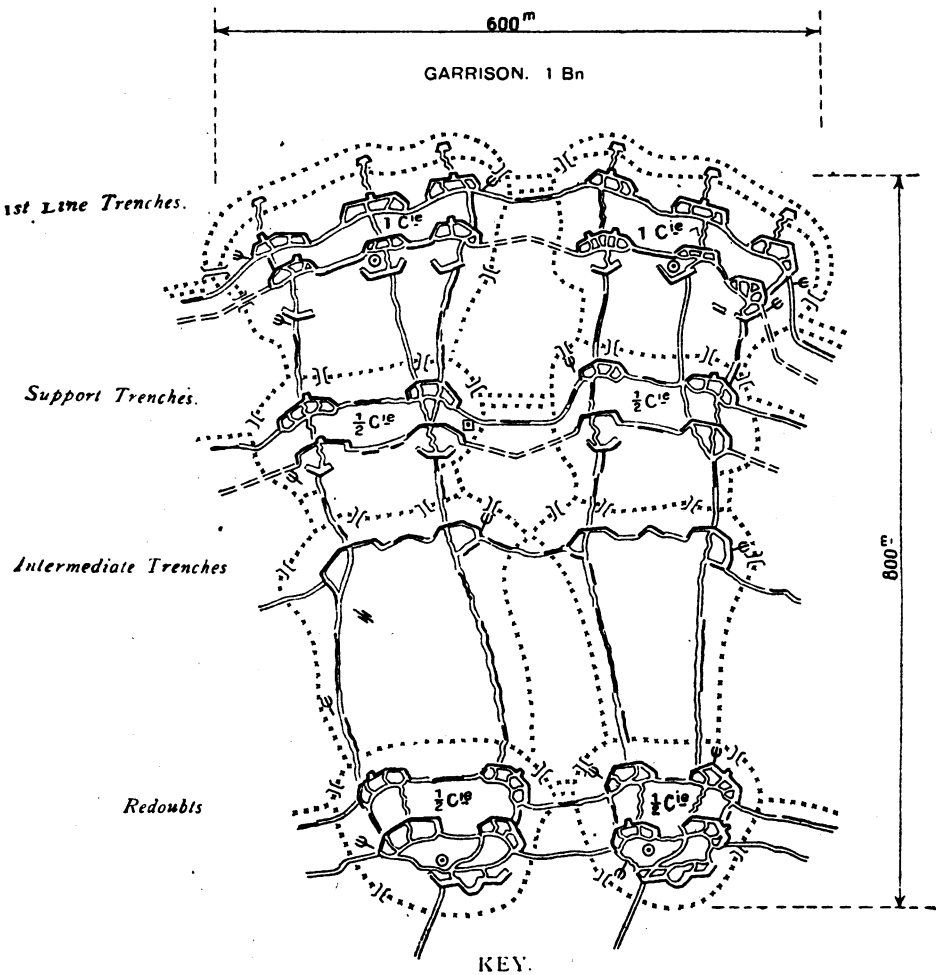
TYPE PLAN OF CENTRE OF RESISTANCE.



KEY.

- *Fire Trenches.*
- *Dummy Trenches.*
- *Communication Trenches.*
- *Machine Gun.*
- *Gun for flanking fire, under cover.*
- *Company Command Post.*
- *Battalion Command Post.*
- *Entanglement, with gap.*
- *Listening Post.*

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the sketch can be seen the difficulty, not to say impossibility, of camouflaging a centre of resistance. It consisted of a series of supporting points, not of geometrical trace, but obvious owing to the density of the earth works, and to the surrounding girdles of entanglement. It was a delusion to think that it could be possible to construct all the works necessary for camouflage, the real works absorbing all the labour available; besides, even admitting the possibility of constructing them, the occupied portions must always have presented peculiar features of their own. Other reasons operated against complete camouflage. The existing obvious *fortins* contained shelters which could not be abandoned, and, besides this, the infantry had begun to understand and apply the pre-war principles of defence. The sappers had made adepts who were only too happy to oppose to the new regulations the knowledge they thought they had gained on the battlefield, and the writer states that early in 1916 his divisional general insisted on his constructing two closed works which realized completely the definition of "shell-traps."

In the December, 1915, Instructions organization in depth was accentuated, and in each *position* there were to be three *lines*—first line, support line and line of keeps. The pre-war arrangement of positions was abandoned and the advanced position had disappeared. The first, or position of resistance, was sometimes doubled by an intermediate position some two or three kilometres in rear, the defence of both of these falling on the infantry divisions in the sector. The second position, five or six kilometres in rear of the first, was held by the reserve Divisions of the Corps or Army, and sometimes a third position was made five or six kilometres in rear of the second, and garrisoned by the reserves of the Army or groups of armies.

In February, 1916, when the attack on Verdun began, the 1915 Instructions had not been completely applied, but the importance of camouflaging the occupation of a position was again demonstrated. The uncamouflaged centres of resistance were at once demolished by a bombardment of an intensity hitherto unknown, the flanking arrangements were destroyed and large gaps opened in the entanglements protecting the passive intervals, by which the enemy entered and turned the centres which still held out, much as in August, 1914. Also, owing to the omission of the advanced line the enemy was able to act with full power on the main position, and the suddenness and violence of his attack entailed heavy losses. At the beginning of the battle the weight of the artillery preparation at first led to admitting the impossibility of holding the first lines, and to considering the counter-attack as the sole means of resistance. The system of partial counter-attacks across the open against an enemy under cover was usual at Verdun in March and April, 1916. A valuable instrument of defence, it must not be hasty, disconnected and only beat the air, but must have a perfectly definite aim, and

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be supported by infantry and if possible by artillery fire, and for these reasons should start from a pre-arranged position.

The battles of Verdun and the Somme quickly modified once more the conception of the power of resistance of the lines. A note by G.H.Q. of 3rd April, 1916, lays down formally the principles of the "infrangibility of the front," which can be obtained first by camouflaging the occupation which induces the enemy to disseminate his artillery preparation fire, and so diminish its intensity. (However, camouflage gradually became more difficult as aerial observation improved, but both at Verdun and on the Somme lines of snipers extended in shell-holes escaped the attentions of the enemy owing to the natural camouflage afforded by the numbers of shell-holes.) Second, by counter-preparation by the artillery. Third, by distributing in depth the troops entrusted with the defence, and organizing a step by step defence, for infrangibility of the front does not imply infrangibility of one line. Fourth, by foresight and pre-arrangement of the counter-attack, which is no longer considered as the beginning and end of the defence, but as a useful supplementary aid in case of rupture of a line. Lastly, the experience gained at Verdun of centres of resistance separated by passive intervals led to the adoption of a more continuous defence.

The Instructions of August, 1917, were inspired by these lessons. By them the position should consist of a series of centres of resistance connected with each other. The centre of resistance consisted of combat groups, grouped to form well camouflaged supporting points. The distribution of troops was not uniform and continuous, but the intervals between the active portions of the line were watched, and practically the passive interval had disappeared. Lastly, the era of camouflage had opened out. The great discovery of August, 1917, was the combat group, the practical value of making *the automatic arms protected by a few men* the backbone of the defence, since experience had proved that the section commander alone could exercise command, and then perhaps not over the whole of his section; it was the commander of the combat group only who could effectively command, hence the combat group became the elementary cell of the defensive organization. For reliefs, discipline, the transmission of orders and information, and for these purposes only, a certain number of combat groups were placed under one chief. It is unfortunate that the terms "centre of resistance" and "supporting points" were retained for these larger bodies; they awake in the mind ideas which had better be forgotten, and it is to this terminology that may be attributed the issue of some recent plans of defences showing centres of resistance and supporting points surrounded by girdles of entanglement which are non-existent at the present day —the girdles even emphasized by bands of colour which seem to

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isolate the supporting points in the defensive system. That the want of exactitude in the nomenclature has received attention is evident, since some armies have coined new terms such as district (*quartier*) or sub-district (*sous-quartier*) for collections of combat groups of the strength of a battalion or company respectively.

From the teaching of actual experience it is proved that the passive zones are the danger points by which the enemy can often penetrate to act on the flanks and rear of the active zones, and it would be of great advantage if these passive intervals were formally forbidden. The August, 1917, Instructions are not definite enough on this point, they do not clearly insist on a continuous defence for fear that it may lead to a uniform distribution of force, but on the other hand in most cases such a distribution has to be adopted, since the resistance of the front must be uniform, and the want of definiteness in the instructions only complicates matters, while the defensive organization should be as simple as possible if it is to be grasped by infantry, who have little time for study, at any rate in time of war.

The August, 1917, Instructions made no alteration in the principles of the employment of the positions. Resistance is always to be made on the first, and the lessons of Verdun and the Somme led to the active construction of third positions, and to increasing the distances between the positions, with a view to preventing the enemy artillery preparation from taking effect on two consecutive positions without the necessity of changing the position of the guns. Six to eight kilometres in lieu of five to six is therefore laid down as the distance between positions, but further experience will prove that this does not meet the new offensive methods.

From October, 1917, to March, 1918, works of defence were pushed on with activity and appliances hitherto unknown, in preparation for the formidable attack expected in the spring when the enemy should have collected all the troops liberated by the defection of Russia. The principles laid down in August, 1917, were everywhere applied. The characteristics of the offensives of the end of 1917 (the British attacks at Cambrai) and of 1918 (German attacks of March, May and July) were the surprise obtained by the use of tanks on the side of the allies, and the extensive use of smoke and gas shells by the enemy. The results of these new methods were that, by means of heavy and sudden attacks, the assailant overwhelmed the first positions, and often arrived at the second before the defenders supplied by the reserve infantry divisions of the Army Corps. Thus on 27th May the enemy was able in a short time to overrun the first position on the Chemin des Dames, cross with rifles slung the well-organized but unoccupied positions on the southern slopes of the Aisne, and in a few days reach the Marne. It would be an exaggeration to say that this far-reaching success was solely due to defective methods of defence; there were other

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causes, in particular the small number of troops in line and in reserve, for—and this requires emphasizing—in fortification as in many other matters the cheapest article is often the most expensive, the economy of force which a sound system of defence allows to be realized must not be allowed to pass a certain limit under penalty of becoming dangerous and sometimes very costly. However, if the principles of organization of a position were not invalidated by these bitter experiences, it must be allowed that the distribution of positions behind one another, and above all that of the troops entrusted with their defence, as laid down in the Instructions of August, 1917, did not meet the case of the sudden heavy attacks of the period, and again that in the position itself the necessity was felt of more continuous defence in order to escape penetration.

To deal with the new methods of offence it was laid down that the simple look-out lines must be replaced by a true outpost position, that the position to be held, the position of resistance, must be at some distance from the enemy's front, and that these two positions must both be held by the divisions in the sector. The position further in rear, the old second position, became the *barrage* position, and was in future to be manned by a simple safety garrison (*garrison de sûreté*), taken from outside the divisions in line, until the arrival of the reserve formations which should start from this position to reinforce the position of resistance, or recapture by counter-attack lost portions of that position. The *barrage* position, as its name indicates, would also constitute a *barrage* in case of rupture of the position of resistance.

All these guiding principles are to be found in notes from G.H.Q.; the following examples will show how they were put into practice. In the Fourth Army at the time of the attack on 15th July, there were no communications or notes illustrating the principles, but their application will remain one of the most memorable tactical events of the war, and was of the greatest use in the re-establishment of the situation. The methodical retreat from the position of des Monts, which had become an outpost position, on admirably organized positions of resistance, and the stubborn resistance on the new position, arrested the left wing of the German attack, and allowed of launching the counter-attacks which the two victorious battles of the Ourcq and Marne actually were. In the Third Army, just before the enemy's attack of 7th June, the army commander reminded the troops that success in the battle depended upon the inviolability of the position of resistance. The first line troops must fight for the retention or recapture of that position; they were not distributed in depth to resist on successive lines, but to constitute reserves intended to fight on that position by reinforcement or counter-attack. The decisive event of the battle would be the counter-attack delivered against the

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enemy's troops when broken before the position of resistance, and would be carried out by the divisions in reserve, which, as far as possible, would not be engaged in the preliminary battle. Two days later the third German offensive commenced, and a few days afterwards General Mangin on the left of the Third Army launched his divisions in a counter-attack on the German right, stopped their advances on St. Just and Compiègne, and for the third time reduced their hopes to nothing.

From the documents just reviewed the organization based on their teaching may be stated as follows :—

A covering position to stop partial attacks, and to delay or break up larger ones. It is defended by a third or a quarter of the infantry divisions in the sector.

A main position of resistance, at least 2,000 metres from the enemy, on which the enemy must be beaten. It is held by two-thirds or three-quarters of the infantry divisions in the sector.

A *barrage* position 6 or 8 km. from the enemy, destined to put a limit to his success, and defended by the reserve divisions which must be stationed as close to the position as possible.

In this distribution the rôle of the positions corresponds to that of the lines in the position. The covering position corresponds to the outpost line, the position of resistance to the line of resistance, and the *barrage* line to the line of strong points, and lastly, the *barrage* position, like the line of keeps, should limit the enemy's progress, and furnish formidable counter-attacks. The principles of the Instructions of August, 1917, are consistently applied, at the same time the defence should be more continuous, and the passive zones or intervals should be suppressed. The normal combat group is the half section, and can be isolated, since it possesses all the infantry appliances. Thus the defence can be drawn tighter without increasing the effectives.

It will now be of interest to formulate the general principles which have governed this evolution; strong points separated by intervals have failed, while continuity of the defensive line is confirmed. The pre-war principle of withdrawing the main position of defence from the immediate neighbourhood of the enemy, and covering it by advanced posts has been returned to. Adverting to the comparison of centres of resistance to the bastions of an *enceinte* we see that at first these bastions, filled with defenders, were isolated; then early in 1915, the curtain, *i.e.*, the continuous trench, was constructed, and futile attemps were made to disguise the too conspicuous bastions. At last, after two years of trial, in August, 1917, the bastions disappeared, and gave place to smaller works scattered along the wall, *i.e.*, along the passive intervals; these are the combat groups hidden in the network of entanglements and trenches.

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PROFESSIONAL NOTE.

TESTS ON BOX GIRDER BRIDGE. Designed by MAJOR G. LE Q. MARTEL, D.S.O., M.C., R.E.

(CONTRIBUTED BY THE R.E. BOARD.)

SINCE the report on this bridge, published in the *R.E. Journal* of July, 1921, the following tests have been carried out :—

(i.) *Light Bridge.*—2 girder ; 96 ft. long ; 93 ft. 6 in. clear span.

A pontoon wagon drawn by six mules and loaded with two ton on each axle was passed over the bridge.

The deflection was :—

1st run, 1½ in.
2nd run, 1 in.

It was noticed that there was a slight vertical vibration on the bridge. It is thought that stiffeners may prevent this, and they will be tried at the next opportunity with a 96 ft. bridge. (*Photo* I. shows the load crossing the bridge).

(ii.) *Tank Bridge.*—3 girders ; 48 ft. long ; 47 ft. clear span.

A Medium B tank (17 tons) was first passed over the bridge. The deflection was 1 in.

A 35-ton tank was passed on to the centre of the bridge and caused a deflection of 1½ in. only.

The bridge was quite rigid under the load.

There were horn beams at one end of the bridge only.

(*Photos* Nos. II. and III. show the two tanks on the bridge).

(iii.) *Launching.*—48 ft. long girder.

The launching gear consisted of a 20-ft. derrick, 9 in. in diameter with haulage tackle of 3-in. cordage on treble blocks and a preventer tackle of 3-in. cordage on treble and double blocks.

No difficulty was experienced in launching.

In Major Martel's notes he advised the erection of shears on the near bank to lower on to its seating.

In launching this girder it was thought that the horn beam would run down the rollers safely if the girder were held by the preventer tackle. This was tried three times and each time was successfully done, but on the last occasion, due to a faulty wire rope connection, the preventer broke. In this operation care must be taken to get a firm bearing for the rollers so that they are not pushed backwards when the horn beam comes on them. The rollers are also a little too narrow for this operation and rather too light.

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A new design of roller is being got out which will make this operation quite safe for longer spans. This will save much time in launching.

(iv.) *Launching.*—96 ft. long girder.

The weight of the girder is about 8 tons. The launching gear was as under :—

Derrick—round spar 24 ft. long, 15-in. diameter.

Back guy—3-in. wire rope.

Side guy—2-in. wire rope.

Back anchorage—12 in. × 12 in. × 16 ft., buried 3 ft. 6 in. in ground.

Hauling tackle—3-in. wire rope on treble blocks.

Preventer tackle—4-in. cordage on treble and double block (no wire rope being available).

Preventer anchorage—12 in. × 12 in. log behind eight 2–1 picket holdfasts.

Hauling gear—5-ton winch, no other being available.

Preventer winch—5-ton winch, no other being available.

Lashing at head of derrick—9 turns of 1¼-in. wire rope, no derrick straps being available.

Rollers—Fixed rollers as designed for this bridge.

It took a long time to rig up the hauling gear as it was all extemporized material.

(*Fig.* 1 shows the launching gear as erected).

(*Photos* Nos. IV., V. and VI. show the girder being launched).

It was thought that the girder would be very whippy on account of its depth being so small as compared with the span, but this was not the case as no sign of unsteadiness was noticed and during the launching the girder could easily be controlled to an inch. When the centre of the girder was on the bank seat roller, and consequently the whole weight of the girder taken at the centre, it was noticed that the ends deflected about 2 ins. ; the top boom was then in tension and the bottom boom in compression.

It is not considered that this deflection during launching is excessive nor that any stiffening is necessary during launching for this span. It took an hour to get the girder across, but this was entirely due to the fact that only 5-ton winches were available and they are much too heavy for the job.

With 2-ton winches the girder could be put across in a quarter of an hour.

(v.) The handrail of this bridge is being re-designed, and further tests are being made to ascertain the effect of stiffening-frames and sway-bracing on the longer span bridges. Additional trials will also be carried out to test the maximum safe length of bridge attainable for each class of load.

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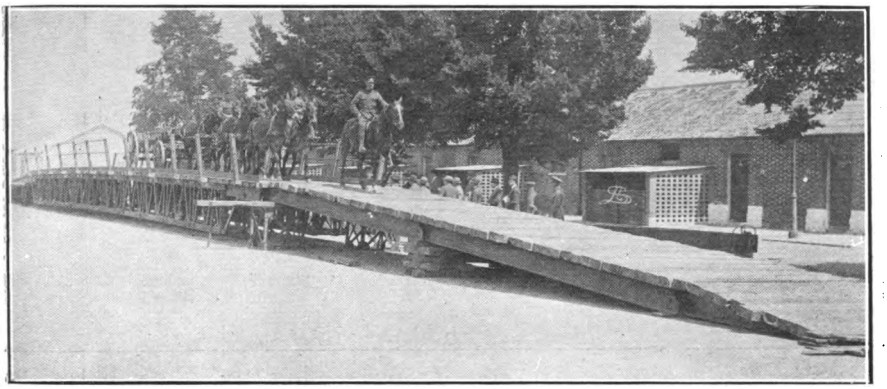
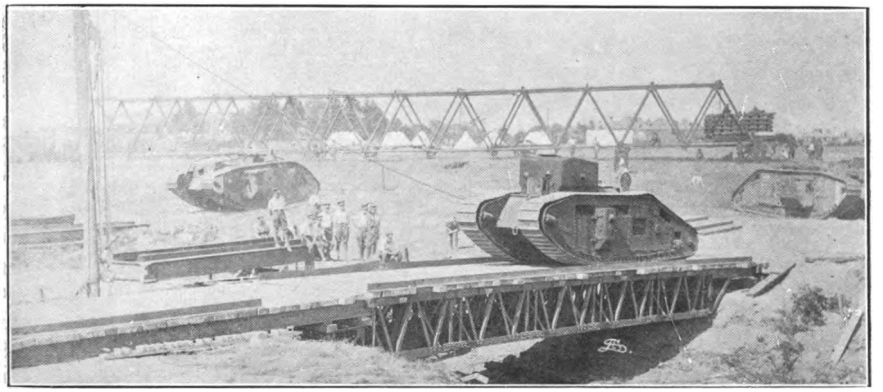
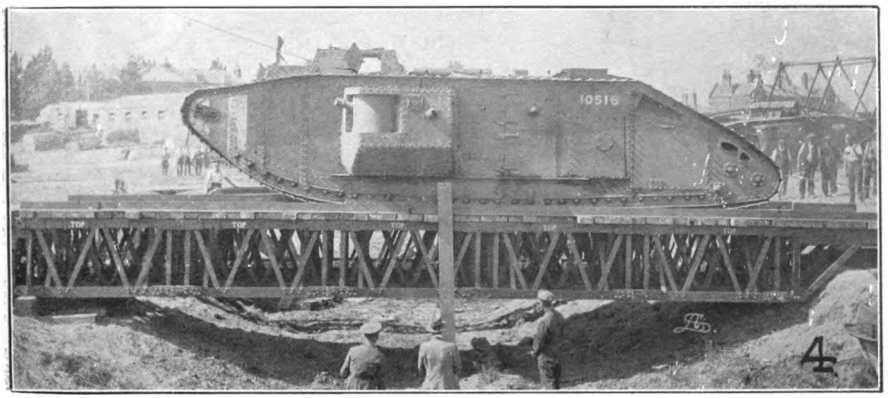
TESTS ON BOX GIRDER BRIDGE.



1.—Box Girder Bridge.
96′ long—2-girder bridge. Load—6 mules and 2 tons on each axle.



2.—Box Girder Bridge.
48′ long—3-girder bridge. 17-ton Tank on bridge.



3.—Box Girder Bridge.
48′ long—3-girder Bridge. 35-ton Tank on bridge.

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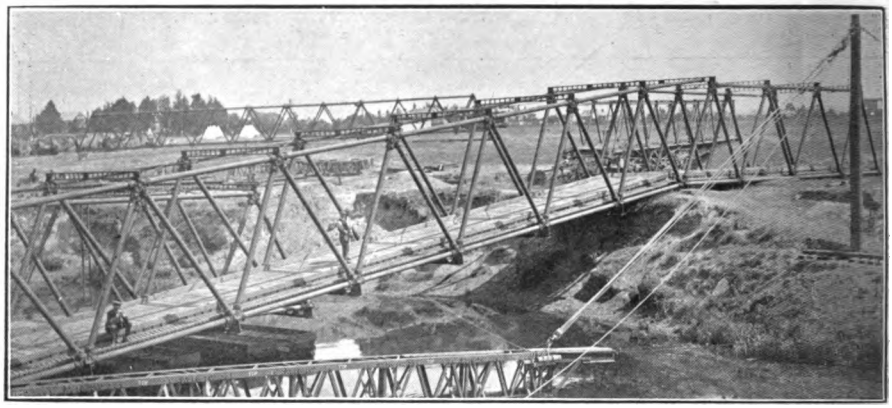

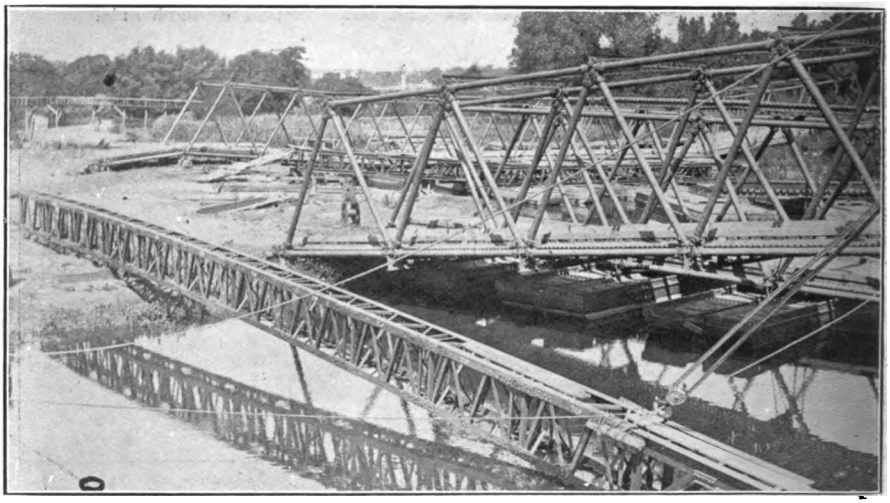

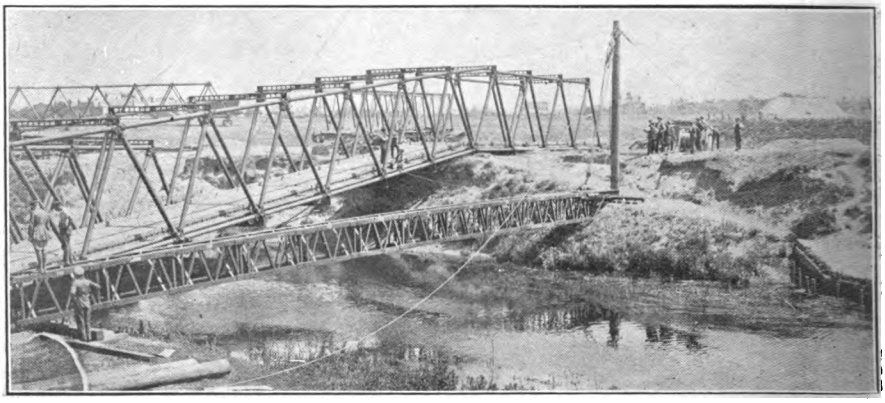

4, 5, and 6.—Box Girder Bridge.
Launching 96′ girder.

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BOX GIRDER BRIDGE. LAUNCHING DIAGRAM FOR 96FT. GIRDER.

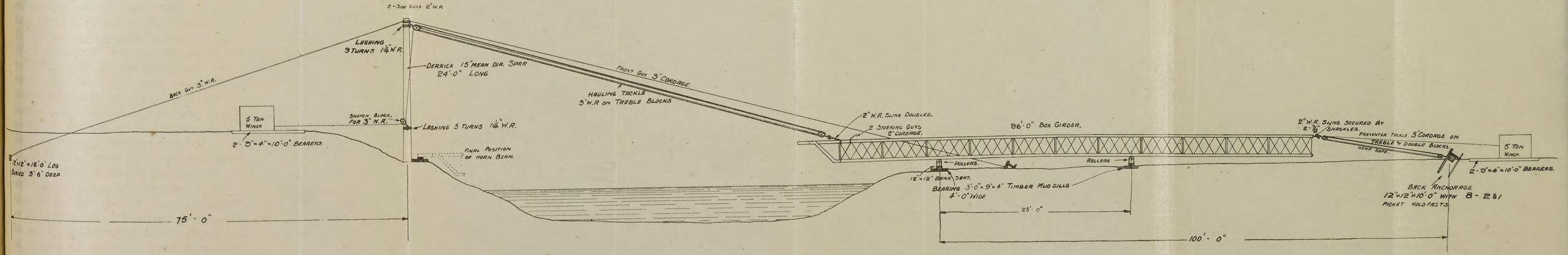
2-Side Guys 2" W.R
Lashing 9 Turns 1¼" W.R.
Derrick 15" Mean Dia. Spar 24'-0" Long
Back Guy 3" W.R.
Front Guy 3" Cordage
Hauling Tackle 3" W.R on Treble Blocks
5 Ton Winch
Snatch Block for 3" W.R.
Lashing 5 Turns 1¼" W.R.
2-9"x4"x10'-0" Bearers
Final Position of Horn Beam.
12"x12"x16'-0" Log Buried 3'-6" Deep
75'-0"
2" W.R. Sling Doubled.
2 Steering Guys 2" Cordage
96'-0" Box Girder.
Rollers.
Rollers
12"x12" Bank Seat.
Bearing 3'-0"x9"x4" Timber Mud Sills 4'-0" Wide
25'-0"
100'-0"
2" W.R. Sling Secured by 2-⅞" Shackles.
Preventer Tackle 3" Cordage on Treble & Double Blocks Hemp Rope.
5 Ton Winch.
2-9"x4"x10'-0" Bearers.
Back Anchorage 12"x12"x10'-0" with 8-2&1 Picket Hold Fasts.

Fig. 1

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MEMOIR.

MR. WILLIAM JOHN SAMPSON.

It is with the deepest regret that I record the sudden death of Mr. W. J. Sampson, Sub-Editor of this *Journal* and Chief Clerk in the office of the Secretary of the Institution of Royal Engineers, which occurred at Gillingham in the early morning of the 6th September, as the result of an operation. This regret will be shared by a very large body of all ranks of the Corps. Mr. Sampson's long service in the office at Chatham, extending over 36 years, made him known to a large proportion of those who passed through the School of Military Engineering, and his unfailing courtesy and readiness to give unstinted help to all who asked it of him cannot have failed to win him the respect and gratitude of very many. He had become almost an institution at Chatham, and in many semi-official and social matters his advice and assistance were almost invariably sought. He possessed two qualities of the greatest value in such matters, almost unbounded knowledge and experience of all that concerned the personnel of the Corps, and the greatest energy and capacity for getting things done. His energy and activity to the last are the more surprising in view of the grievous state of his bodily health which was revealed in his last illness, but of which his cheerful and loyal personality would allow no sign to appear. His zeal for the *Journal* was immense, and his pride in it, which in its present form he had nursed from its first number, was almost a fetish. He had many influential friends and I believe he could have obtained with ease employment far more lucrative, but he was deeply attached to the *Journal* and I am sure that it was as he most desired that death should have found him at his post and engaged upon the work which he so loved and honoured. He took especial pride in the punctuality of its appearance and it is pleasant to look back upon the oft-recurring comedy when important "copy" would arrive at, and even beyond, the eleventh hour. It would be met by him at first with a mask of absolute impossibility, to be followed by most helpful collaboration and finally by such energy and management as could not fail to produce the amended number with its usual punctuality. His intimate knowledge of all branches of the printing and publishing profession was invaluable and he always gave of his best and in the most gracious manner. It is hardly too much to say of him that "he has made a chasm which . . . nothing can fill up."

F.E.G.S.

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REVIEWS.

HINTS TO TRAVELLERS (10TH EDITION).

(Two vols.). Published by the Royal Geographical Society. Price 21/- net. (To Fellows of the Society 15/-).

In a Preface to the Tenth Edition of this indispensable *vade mecum* for explorers Mr. Arthur Hinks explains that the first volume, "Surveying and Practical Astronomy," has received no serious alteration, a few passages only that were obsolete have been omitted, and brief references to new methods, such as Longitude by Wireless Time Signals, have been inserted. This volume, it may be remembered, contains a grateful tribute by the author, Mr. E. A. Reeves, Map Curator and Instructor in Survey to the Society, to the assistance he had received from Sir Charles Close's standard work. In the second volume the notes on Photography have been thoroughly revised, a note on Anthropology has been added to the Natural History Section, and the memorandum on Glacier Observations has been revised. The Medical Hints which occupy 130 pages have been practically rewritten. Other interesting sections are on Meteorology, Geology, Industry and Commerce, Archaeology, Canoeing and Boating, Orthography of Geographical names, all written by first-rate authorities. The book has been placed in the Corps Library.

F.E.G.S.

MATÉRIELS ALLEMANDS ET AUTRICHIENS À GRANDE PUISSANCE.

(Paris, Berger-Levrault, 7.50 francs.)

This apparently official book—there is no indication of authorship but it is stated that "This study replaces the 'Notice sur les matériels allemands de gros calibre du 14. 7. 1917'—describes and illustrates with 117 Diagrams and Plates the German and Austrian guns and ammunition of 5·9 inch calibre and upwards, with their means of transport, platforms, etc. It forms a valuable book of reference at a very low price, and seems very complete except as regards the 21-cm. long-range gun which bombarded Paris in 1918. With reference to this only conjectures are offered, "on possède peu de renseignements sur la pièce" and "contrary to the stipulations of the protocol of the armistice accepted and signed by the German plenipotentiaries on 11th November, 1918, the Germans have not handed over to France any of the heavy guns which fired on Paris."

J.E.E.

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NOTICES OF MAGAZINES.

JOURNAL OF THE SOCIETY OF ARMY HISTORICAL RESEARCH.

Whether the world itself is large enough to contain another Society or to support another Journal, may be a matter of conjecture, but the movement which is on foot in the Secretary's office of the Royal United Service Institution to form a Society of Army Historical Research will find many sympathisers. The proposal had almost materialized in August, 1914, and was recently reconsidered, with the result that a subscription list was opened at 10/- a head, and it was decided that if 80 subscribers were obtained two experimental numbers of a Journal, each containing 32 pages, should be published. The appeal produced 153 subscribers, and the first number of the Journal appeared on the 1st September. It bears the high standard of the publications which emanate from Sir A. Leetham's office, and has an attractive title-page copied from the English translation, published in 1560, of Machiavelli's "The Art of Warre." The contents are full of interest and the Journal, if it receives the support which it deserves, should become a military *Notes and Queries* which may be counted upon to contain information not only interesting but of high historical value. Major H. G. Parkyn, O.B.E., is Honorary Secretary of the new Society.

F.E.G.S.

MILITAR WOCHENBLATT.

No. 5.—*Law Dealing with Care and Re-settlement of Ex-members of the Reichswehr.*—In view of the fact that the officers of the Reichswehr will normally serve for about 25 years, and the other ranks for 12 years with the colours, it has been thought necessary to make special provision for them when they shall return to civil life. Help will be given under many different headings and the scheme has been devised so as to cover every deserving case. Re-settlement on the land is made a great feature. Officers' pensions seem to be on a fairly liberal scale, rising from 35% of their pay on retirement after a minimum of 10 years' service, to 75% after 35 years. The latter will, however, be only rarely attained.

The Sinking of the German Fleet at Scapa Flow.—"In the rush of events connected with the collapse of Germany, the passing of the German Fleet into internment passed almost without any outward expression of feeling; when, however, Admiral Reuter saved the victors of Jutland from ignominious surrender by sinking them to the bottom of the sea, the nation saw that its honour was saved and breathed a great sigh of relief." This is how the *M.W.B.* comments on Admiral Reuter's description of his exploit, which has just been published. The Admiral declares that the English officers never really believed that the German Fleet would actually arrive across the North Sea, and, as a patriotic

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people, could not understand how such a miserable surrender could be made. The actual sinking was a difficult task, because the fleet was permeated with revolutionaries, whose interference had to be carefully guarded against.

No. 6.—*The Austrian Defence Force.*—Further progress has been made with its re-organization. By new pay regulations 19 rates of pay are instituted, to cover all ranks from private to general; the rates, however, depend on employment and not on rank. The whole cost of the force amounts to 3% of the national income, or rather of the national expenditure, which is a very different thing. Out of 49 milliards estimated national expenditure, pensions, etc., absorb 14 and food subsidies 10½ milliards, while the defence force uses 1½. Rations have recently been improved considerably, at a cost of 100 millions, and are now quite good. Insurance for all ranks is compulsory and, for all except the private soldier, is on a contributory basis.

The Soviet Army.—This is credited by the *M.W.B.* with a total of about 450,000 men, divided into six main army groups, as follows :—

In the neighbourhood of Petrograd	45,000
Between the Duna and the Pripet	90,000
South of the Pripet	100 to 150,000
In South Russia, excluding Budienny's Cavalry Army ..	40,000
In the Caucasus	70,000
In Siberia	70,000

The value of the Armies has considerably improved, thanks to the way Trotsky has been able to utilize the services of the old officers, and especially of Brusiloff, who is now reported to be in charge of large movements in the neighbourhood of Novo-Tcherkask, and Tzaritzin, destined to help the Nationalist Turks. So long as this unnatural alliance holds, the *M.W.B.* does not expect any attack will be made on Poland.

No. 7.—*The Raid of the 5th French Cavalry Division during the Battle of the Marne* (1914).—This division formed part of Sordet's cavalry corps which was under General Manoury's orders during the Battle of the Marne. It was still quite exhausted by the exertions of the past month, but nevertheless was ordered to send one division round the German right flank, to fall on von Kluck's rear about La Ferté Milon. The 5th Division accordingly rode off, and got right in rear of the Germans. The French declare that its action was of great importance, and that to it von Kluck's decision to retire was largely due. This opinion is strengthened by the story of a meal, prepared for 42 officers of von Kluck's headquarters at the Château of Ancienville, and left untouched because of the approach of the 5th Cavalry Division.

General von Kuhl, who was von Kluck's chief of staff, disposes of the dinner story by declaring that he was with the staff the whole time, and that they never entered Ancienville. As regards the influence of the cavalry on von Kluck's decision, he declares that what took place was as follows :—On the afternoon of the 8th September the whole of Army Headquarters was moving towards La Ferté Milon, so as to be in close touch with the right flank, where a decision was to be sought on the following day. As the long string of motor cars was nearing its destina-

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tion some surprise was expressed at not seeing the heads of the columns of the IXth Corps, which were then expected. At the same moment a few gunshots were heard not far off, and the presence of hostile cavalry was at once suspected. The whole of the Army Headquarters got ready to defend itself, and some officers were sent out to reconnoitre. Before, however, these could get any touch with the French the head of theIXth Corps appeared on the scene, and was followed into La Ferté Milon by the Army Headquarters. Von Kuhl says it is true that the cavalry nearly captured Army Headquarters, owing to the carelessness of the latter in pushing ahead of their infantry, and a wonderful opportunity was let slip, but as things turned out their presence had no influence on von Kluck's decisions. The latter, as is well known, were due to the intervention of Lieut.-Colonel Hentsch and the withdrawal of the 2nd Army.

The cavalry spent the night of 8th/9th September about six km. N.E. of La Ferté Milon and marched off westwards to Verrines on the 9th. A few ammunition and supply columns were diverted or delayed on account of their presence, but there were no other results.

Von Kuhl says he was very much afraid that French cavalry would make a dash for the Aisne crossings about Soissons and that he despatched the 4th German Cavalry Division to forestall any action of this sort. He thinks that the raid as a whole was badly conceived and badly carried out, and that the proper place for the French cavalry was the decisive point, *i.e.*, the left of Manoury's army, and not on a wild-goose chase in the forest of Villers-Cotterêts. Above all was it the duty of the French cavalry to hold off Lepel's brigade, which was advancing from Baron to Nanteuil-le-Houdain and threatening Manoury's rear.

It is, however, difficult to see how the 5th Division could, without the most extraordinary good luck, have known of the proximity of von Kluck's Headquarters or be blamed for not going for the Aisne crossings, when a general German retreat was the last thing anyone was expecting. As for the German cavalry, von Kuhl says it was wrongly placed from the first, and in consequence was absent at the decisive moment, and did not fulfil the hopes that had been fixed on it.

Treaty between Poland and Roumania.—The *M.W.B.* is surprised that Roumania has identified herself with Polish interests. While she must sooner or later settle with Russia regarding the frontier of Bessarabia, yet her claims are so strong in this respect that she will almost certainly make them good. Poland, on the other hand, will never be able to maintain her eastern frontier, and does not deserve to do so. Roumania has, therefore, associated herself with a losing cause which even the French cannot support, without any adequate compensations, and Poland will be led once more to ignore realities and take up an impossible line of action.

No. 8.—*The Supply Situation in the German Armies on the Western Front in November*, 1918.—General Groener who was responsible for food supplies, told the Kaiser in November, 1918, that the German armies were in danger of starvation. This statement has recently been criticised and one writer has declared that stocks, that would have maintained the armies for several months, were left behind to fall into the hands of the Allies. The experience of the British Army certainly does not bear this

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out, and the *M.W.B.* declares that Groener was quite right and that the armies were living from hand to mouth. Oats were practicablly unobtainable, and the condition of the horses was deplorable. Much embarrassment was caused by the terms of the agreement made with the Spanish-Dutch relief committee, which prevented proper exploitation of the resources of the occupied territory, and the revolution in Germany prevented the free movement of such supplies as were to be found in Germany.

No More Medals.—The Government has decided that no more medals are to be issued, even for life-saving, long service or any other reason.

Concealment of Arms.—Colonel Repington's statement, in the British Press, that many Germans are willing, for various reasons, to give away the hiding places of arms, and thus facilitate the work of the Allied Missions of control, makes the *M.W.B.* very sad. It says that no Englishman, Frenchman or American would act in such a way, and that Germany can never rise so long as she harbours such traitors.

No. 9.—*Re-Union of Front-line Fighters.*—A big meeting was recently held in Berlin to bring front-line fighters together again. General von der Goltz made a speech welcoming them, and General Ludendorff also. After much music, cheering and patriotic demonstrations the meeting, at which 25,000 men were present, dispersed.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE DU GÉNIE MILITAIRE.

March, 1921.

French Engineers in Poland, April to November, 1921.—This article describes the training of and the work done by the Engineers of Haller's Army. These engineers consisted of Poles from America, Polish prisoners of war captured on the French and Italian fronts, and a few French officers and N.C.O.'s. Descriptions are given of the construction of four bridges of 100, 70, 52 and 20 metres respectively.

April, 1921.

The Protection of Military Buildings against Fire.—Questions of construction are gone into, also fire fighting appliances, and finally fire discipline.

Organization of Work.—French Headquarters laid down very little about this subject—(1) Too great dispersion removes the men from the immediate and actual control of their officers; (2) work should be prepared and regulated.

Preparation means making a definite plan, marking out the work and supplying tools and materials before the arrival of the men.

Regulation means carrying it out as a military operation, under the orders of officers and ensuring continuity.

Organization requires (*a*) *orders*, which must be capable of being carried out; improvisation is the negation of organization. These orders must contain the result required and orders as to execution with details of personnel, material, transport, routes, etc. (*b*) A *definite plan*,

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which must include the task of each unit and should be prepared by the commander concerned. (*c*) A *reconnaissance* of ground, resources, the conditions under which the work is to be carried out, transport difficulties and dumps. (*d*) A *commander* not to be changed during the progress of the work. Dual control must be avoided. This commander should be the commanding officer of the personnel.

Hence it is better to give a definite task to a complete unit rather than to detail so many men to a task.

Preparation of the Work.—1. The commander must get into touch with the man for whom the work is being done.

2. The commander should prepare his plan based on reconnaissance of ground and material, the order of urgency, the successive arrival of stores, and should arrange for a reserve both in men and material.

3. He will prepare detailed written orders for each task to avoid any possibility of mistake.

4. He will ensure continuity of work by arranging for (*a*) the tasks to be marked out ; (*b*) the arrival of tools and materials ; (*c*) the arrival of the personnel as required ; (*d*) he will get into touch with the personnel to direct operations and to clear up doubtful points ; (*e*) he will continually superintend the work so as to know progress, to equalize the work by using his reserve, to ensure the best use of his resources, to improve the organization and to develop the interest and the work of the personnel ; (*f*) he will obtain progress reports which should be reports of total work done to date and not of work done per relief.

Execution.—This depends for success on the suitable subdivision of the work down to corporals and lance-corporals, the use of the right men for the right job, on avoiding alterations in the plan, and on constant supervision. Give immediate praise when deserved, never give too large tasks and give rests at regular intervals.

The Use of Engineers.—The engineer is the reserve to the Command and the help of other arms. He makes out the programme, prepares and, if necessary, shows the work to be done, takes his share of it, supplies materials and gives technical advice.

He should ensure continuity of work at times of relief, organize the work for the Infantry, but leave the carrying out of it to them under their own officers whilst supplying them with tools and materials.

More technical work, such as certain shelters, bridges, concrete engines, tracing of trenches, communication trenches, obstacles, demolitions, drainage, etc., may be given to him to do.

Also certain works of general use not actually in the sphere of any particular troops, such as main C.T.'s, roads, huts, command O.P.'s, Headquarters of Brigade and higher formations, aid posts, wells, streams, etc.

Also in cases of extreme urgency the engineer can be used as a reserve of labour.

The principal of engineer supervision by individuals is thoroughly unsound. On the other hand, an officer or N.C.O. can be very useful for *liaison* work and to ascertain requirements. He gives the Infantry the impression of material and moral help and at the same time keeps in touch with the situation on the front and the progress made.

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Individual supervision leads to dispersion without increasing results, as it destroys the fundamental principal, the responsibility of the commander.

Engineers are troops like any other and should work in definite units under their own officers, the smallest, the section; the normal, the platoon; the ideal, the company.

Engineers are never numerous enough to undertake all that has to be done at the same time, consequently the commander should lay down an order of urgency and the numbers necessary for a task should be definitely earmarked for it.

If, as occasionally may happen, engineers have to be lent to another arm, it should not be so many men, but such a unit for a definite period.

At other times other units have to be attached to the Engineers to leave the latter free for technical work, and in this case each unit should have definite orders from one commander.

There are two extremes—battle, and stationary warfare—and the situation may be anything between these.

In the former the one objective is to obtain quickly a first result which may be improved later; the troops are ignorant of the ground, the work is urgent and under fire. This requires complete tactical units with their officers and N.C.O.'s. In stationary warfare more dispersion is allowable to obtain the full advantage of trades, but control must still be kept.

The senior engineer officers of Divisions, Corps and Armies have a triple rôle to play: commanders of troops, technical advisers and control over material, workshops, etc. As commanders their functions are to save their men from all unnecessary fatigue and to obtain the maximum result from their work. As technical advisers they should participate in the writing of orders, and, as an integrate part of the staff they should be as much the general's representative on questions of work as the artillery commanders are on questions concerning the use of guns. They are not only there to execute orders, they should help in their conception. The framing of a good order necessitates knowledge of how to carry it out. The solution is the inclusion of the Engineer Commander in Command Headquarters.

The article concludes with some remarks on Taylor's and Gilbreth's attempts to hasten work by the elimination of useless or badly carried out movements.

C. LA T. T. JONES.

REVUE MILITAIRE SUISSE.

No. 4.—*April*, 1921.

The Evolution of Methods of the Offensive.—The original article consists of a paper read by Lieut.-Colonel H. Corda before the Sociétés d'Officiers of Zurich and Lausanne in March last. The author of the paper traces the course of events in the western theatre during the Great War. Military doctrines and technique, the objectives of an attack and the methods employed in carrying the same out, the armament of the troops, etc., were, he points out, continually undergoing change, but all

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the operations of the war pivoted upon the old principles, which still remained immutable. Some of the most remarkable features of the war were those which were due to the great developments which took place in the scientific and technical spheres ; almost every new month brought with it some new invention in the fields of chemistry and physics to the aid of the belligerents. However, the new engines of warfare which made their appearance retained their value but for a very short time ; indeed, only such time as an opponent required to discover the appropriate neutralizing agencies, generally a matter of a few weeks only by reason of the high state of efficiency of modern industry. Although, on the one hand, resort was once more had to weapons of antiquity (*inter alia*, the catapult and the cross-bow), on the other, considerable advances were made in the design of new types of artillery, which continued to make progress in matters affecting the calibre, power, and range of the pieces. Again, whilst hand-grenades and incendiary methods of the middle ages were re-introduced, all the latest improvements in the field of chemistry, *e.g.*, poison-gas shells, were also called in aid. Finally, every means were taken to utilize the features of the terrain ; concrete and all the refinements of permanent fortification were adapted for the purposes of field defence ; contemporaneously, all the old methods of siege warfare were also again seen in full use. Although, in the final stages, the war was brought to a close as it had been begun, that is to say, without the use of wire entanglements, without resort to trenches and approaches thereto, and, practically, without the use of siege artillery, nevertheless, the war was essentially an engineers' war.

The object Colonel Corda had in view in preparing his paper was to indicate the process of evolution which was going on throughout the war in the tactical domain, and more particularly in relation to the developments which took place in the methods of the offensive adopted by the French Army. He traces the various steps by which, both in the French Army and in the German Army, it was sought to attain the effect of surprise ; he further deals with the problems which were, in consequence, put up to the artillery for solution. The paper is an interesting one, and in it are discussed the " problem of piercing the enemy's front," a subject which was so much debated during the three years that trench warfare lasted ; the experiences of the troops of the Entente during the first winter (1914–1915) ; the events of 1915 ; the great events of 1916—Verdun and the Somme ; the events of 1917 ; views held towards the end of 1917 as to the methods by which the enemy's front could be pierced. The operations at Riga on the 3rd September, 1917, when the then relatively new invention of poison-gas shells was made use of on a large scale, and those at Cambrai on the 20th November of the same year, in which 360 tanks took part, are touched upon. This part of the paper closes with a short account of the evolution of ideas on the subject of the defence, as matters stood at the end of 1917. (*To be continued.*)

The Strategical Position of Switzerland as a Member of the League of Nations.—The article on the above subject, by Colonel Feyler, begun in the March number of the *Revue*, is concluded in the number under

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notice. The strategical position of Switzerland is discussed under two heads:—(1) in the circumstances existing at the present time; (2) as it will be if and when Germany is admitted to membership of the League. By the Treaty of Versailles the victorious nations have reaffirmed their intention to respect the neutrality of Switzerland, and have, at the same time, imposed upon the defeated nations a condition that they too shall do likewise. Austria has expressed her willingness voluntarily to accept this condition, but Germany holds out against it. Colonel Feyler points out that in these circumstances Switzerland is threatened, at the present time, with invasion along about 150 kilometres of her frontier, roughly from Constance to Basle; he discusses what dispositions of the Swiss Army would best meet the contingencies of an European War—should one take place in the near future. He next deals with the situation (in relation to Switzerland's strategical position) as it will be if and when Germany is admitted to membership of the League. It is evident that Switzerland's position to-day is very different to that created by the declaration of neutrality made in 1815. Colonel Feyler extracts, from the Declaration of London, the following as being the essential points bearing upon the rights and obligations of Switzerland:—(1) the principle of neutrality is incompatible with the principles of the League of Nations; (2) Switzerland is now placed in an altogether unique position; (3) the League must abstain from moving its troops through Switzerland and also from making military preparations of any kind upon Swiss soil; (4) but the Swiss people can no longer remain inactive, in a military sense, when the question of defending the principles of the League is involved. Colonel Feyler recognizes that it is for the Confederation to consider how the claim of the Swiss Government to sovereign rights in military matters is to be reconciled with the obligations imposed upon Switzerland now that she is a member of the League of Nations.

NOTES AND NEWS.—*France.*—A special correspondent contributes a note upon the provisions made in the Budget for the maintenance of the French Army. The estimated expenditure upon the French Army in 1921 is expected to reach the sum of 6½ milliard francs, an increase of 1½ milliards as compared with the expenditure incurred in 1920. On the other hand, there is to be some reduction in the establishment of the French Army; as compared with 1920 there will be in 1921 8,584 officers, 9,070 men and 6,229 horses less. The dispositions of the French Army for 1921 are stated to be as follows:—In France, Algeria, and Tunis, 28,052 officers, 416,876 men, and 116,735 horses; in Morocco, 2,912 officers, 102,234 men, and 29,761 horses; Army of the Levant, 2,384 officers, 76,877 men, and 23,460 horses; Army of the East (in Constantinople and neighbourhood), 532 officers, 11,544 men, and 2,236 horses; Army of the Rhine, 3,094 officers, 84,948 men, and 23,783 horses; in territory to which the privilege of self-determination has been granted, 370 officers, 10,000 men, and 3,600 horses; in the basin of the Sarre, 266 officers, 7,193 men, and 1,671 horses; special missions to foreign countries, 858 officers and 1,374 men.

W. A. J. O'MEARA.

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THE TRAGEDY OF LORD KITCHENER: BY REGINALD VISCOUNT ESHER.

By COLONEL E. M. LLOYD.

IN July, 1916, the *National Review* contained a sketch of "Lord K." written by Lord Esher, and this was reprinted in the *R.E. Journal* of December. The sketch has now been enlarged and turned into an elaborate study of the last two years of Kitchener's life. The title is prompted, not by the tragic circumstances of his death, but by the painful ordeal of his work at the War Office. "To the poet's vision the tragedy of Hamlet lay in the hero's consciousness of his own irresolution, and not in the holocaust of death amid which the play ends. Lord Kitchener's tragedy was not dissimilar, inasmuch as he realized that the qualities of mind and character which had served him well through life were under these entirely new conditions out of place." That he found himself at a disadvantage as a Cabinet Minister with nimble-witted and voluble colleagues cannot be questioned; but considering what he did towards winning the war, the parallel with Hamlet is not a happy one.

In most respects Lord Esher is very well qualified for the task he has set himself. He was an intimate friend of Kitchener and had a large acquaintance with the politicians who played a leading part in the war. Living in London or Paris, and semi-officially employed, he had opportunities of learning much that was hidden from the world at large. He kept a journal, and his book is based on entries in it, "gathered into something like a coherent form, but uncorrected and unrevised." He writes pleasantly and skilfully, eschewing tedious detail, and it is not surprising that his book should have been well received. As *The Times* remarked the other day:—"The present age loves historical biography, and under the plea of frankness takes a rather mischievous amusement in seeing idols overturned." It would be unfair to suggest that Lord Esher has had any such aim. He tries to give a true picture, without partiality, favour or affection, but he and his subject were not sympathetic; and probably many readers will say as they put the book down: "I always thought so, a much overrated man."

Tennyson said to J. R. Green, the historian, "You are the most vivid man I ever met, you are as vivid as lightning"; but Green was charged with inaccuracy. The artistic temperament forms its

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pictures, and is apt to ignore facts that do not fit in with them. At the outset of his book Lord Esher tells us :—

"*Arabia deserta* seems to me to be the key of Lord Kitchener's character and methods. . . . The Spirit of the Sand, like the Spirit of the Sea, puts an unconscious constraint upon the nature of man. Lord Kitchener's aloofness, patience, slowness if you will, were the outcome of life lived in solitude where the passage of time counted for very little. . . . The slow processes of the Orient were burnt into him by the Egyptian sun."

This suggests an anchorite of the desert rather than one of the most strenuous of British soldiers. But Lord Esher finds in it a clue to his action as War Minister in the much-vexed question of high-explosive shells. The staff at the War Office were surprised at the demands made by Sir John French, and could not realize the actual conditions. "It was all so utterly unlike the unbroken desert over which Lord K. rode to the Atbara or the clean gradients of the Veldt." This "curious lack of imagination and flexibility" was the cause of the delay in supply. He ignores the statement made in the War Office letter of 19th January to Sir John French :—"The Council desire to emphasize the fact that the orders for manufacture are not being limited by what they think it necessary to supply, but are entirely conditioned by the highest possible output of the ordnance factories throughout the Empire and the trade of England, and the Allied and neutral countries of the world." But the contractors, at home and abroad, were unable to fulfil their contracts, and of the H.E. Shells ordered (half a million) only about one-tenth were supplied by the dates agreed upon.

Another point on which the War Office laid stress was that shrapnel was still needed, and that to convert shrapnel into H.E. factories would mean that there would be no output of either for ten weeks. Lord Esher takes no account of this, and contrasts France with England without making any allowance for the difference in the scale of their armaments before the War. To improvise an army of millions and at the same time provide it with new kinds of guns and projectiles in vast quantities was a staggering task. No doubt there were failures and mistakes, but the blame for them must fall not so much on the men then in office as on their predecessors. At all events, before a man passes judgment on them he ought to show that he has been at pains to read what has been said on both sides instead of trusting to entries in his journal.

The question of munitions was soon followed by the question of men. In the first twelve months of the war the army had been brought up to two and a half millions by voluntary enlistment. It was a wonderful achievement, but the stream of volunteers was beginning to fail, and it could be foreseen that to maintain and increase the forces in the field compulsory service would soon be

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inevitable. But the opposition to it was strong in the Cabinet, in the country, and especially among the working-classes. In the autumn of 1915 Kitchener conferred with Mr. Arthur Henderson, and obtained assurances that if it was necessary for victory, and was not to become a permanent practice, it would not be opposed by the Labour Party as a whole. Kitchener thought it best to acquiesce in giving the voluntary principle a last trial by means of the Derby scheme. It meant a delay of three months, but during those months the machinery was created which enabled compulsion to be put in force, and the yield of Derby volunteers was not inconsiderable. Lord Esher blames Kitchener for not giving his colleagues of the Cabinet a clear lead and says he "appeared vague and unsettled." But the Compulsory Service Bill, so adroitly piloted by Mr. Asquith through Parliament in January, 1916, might have suffered shipwreck if the pace had been forced.

Lord Esher tells us that "the position taken up by Lord Kitchener, supported by Sir William Robertson, was that every available man was now required for the army overseas, but that it was not the business of the War Office to fix actual numbers required, or suggest the method by which the men should be obtained. They had convinced themselves that the political conditions of the struggle over compulsion were such that it would be the height of imprudence to give the opponents of that solution of the recruiting problem, which was the only possible solution left, the advantage they would derive from a cry of 'militarism' which would be raised immediately if the protagonists of the proposal were found to be soldiers."

Who shall say that they were wrong? The mere passing of the measure had a great effect in France and Germany; its defeat would have been disastrous.

There is much in this volume that is of interest in relation to the question of "unity of command." It was mooted by the French again and again, of course on the assumption that the directing chief would be a Frenchman. But the occasional divergence which made it seem so necessary was apt to arise in cases—such as the autumn offensive in 1915 and the Salonika expedition—in which the French view was largely governed by political considerations, and the balance of parties in the Chamber. What answered admirably in the special circumstances of 1918 and under the leadership of Foch would have been harmful in the earlier years of the war.

Lord Esher is apt to be inexact about details. Kitchener's familiarity with the French language was gained by two years of school in France and Switzerland, not by his brief service under Chanzy. Lord Roberts is spoken of as over seventy years old when the war began; he was close on eighty-two. The staff which Kitchener found at Whitehall hardly deserved to be described as consisting almost wholly of "aged and tired men." His account of

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the first meeting of Kitchener with Lord Morley differs materially from that given by Lord Morley himself in his "Recollections." Kitchener was most anxious to go to India as Viceroy, an appointment which rested with Morley, as Secretary of State for India. Lord Esher arranged a dinner to bring them together. But things went ill. "Lord Kitchener, either from shyness or pride, shocked the political sensibilities of his principal host, showed himself at the worst, and ruined in a short hour his prospect of attaining his heart's desire. That night, supposed to be guarded and silent, he was lush of talk, with a copiousness of indiscreet opinion, praise and blame, that made Lord Morley say afterwards, 'Never, never shall he go to India.'" Lord Morley's account is less dramatic. He had made Kitchener's acquaintance before this dinner, having had a visit from him at the India Office. He found him "the most cheerful and cordial and outspoken of men, and he hammered away, loud and strong, with free gestures and high tones. . . . We got on very well indeed, he and I, for nothing was said about his going back to India as Governor-General." Evidently Lord Morley's decision was not due to shock, but was a settled purpose, based on quite other grounds than Kitchener's volubility.

But details are of less importance than general truth of characterization. Lord Esher says most aptly: "Just as Lord K. saw things in a truer light from afar off, so his was a figure that loomed larger and in truer perspective at a distance. For this reason his character and aptitudes were more accurately judged by the masses of the people than by his colleagues." Lord Esher himself stood too near to his subject, and was more impressed by blemishes than by the figure as a whole.

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PONTOON EXPERIENCE IN MESOPOTAMIA.

By CAPTAIN AND BREVET-MAJOR F. V. B. WITTS, C.B.E., D.S.O., M.C., R.E.

1. Now that the re-design of the Service Pattern pontoon is under consideration, experience gained in Mesopotamia may not be without general interest.

2. It is first necessary to explain what the special conditions out there were, and then how they were met.

(*a*) Bridging sites on the Tigris and Euphrates were anything up to five hundred yards long.

(*b*) During the winter and spring both rivers are liable to sudden fierce floods, involving rises up to ten feet in the twenty-four hours and over twenty feet in all. On these occasions the current rises to 6 or 7 knots. Many bridges were washed clean away or swamped where they stood: the only safe course, if sufficient warning was obtained, was to completely dismantle the bridge.

(*c*) Violent gales frequently endangered a bridge even when the current was not at its highest. If the wind was blowing downstream, a bridge would be completely hidden by a sheet of spray. If upstream, the bridge would be so violently thrown about as to be impossible to stand on; the sappers on duty were known to be seasick, and occasionally the superstructure worked loose and was thrown into the river.

(*d*) Arrangements were necessary to permit of regular river traffic. A broad river steamer with a large barge lashed on each side, coming down with the stream and often swinging round corners close above the bridge, required a cut of one hundred yards: even then serious accidents were frequent.

(*e*) A light armoured car was the heaviest load provided for in bridge. On occasions when the few heavier guns or lorries in use in the country had to be moved across, rafts were built for ferrying.

(*f*) Circumstances necessitated the material of the bridging trains being used for semi-permanent bridges during the long halts after each stage of the advance upriver—during months on end in the hot weather.

(*g*) There were no roads worthy of the name in the country.

(*h*) Conditions did not permit of the locking up of the large amount of bridging transport required. When not actually required for bridging work, it was frequently in use for general transport.

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(*i*) The material supplied was of the standard pattern but often made in India, and then proved very inferior in every way.

3. (*a*) To meet the above conditions, "Bridging Trains," of which there were four with the Force, were equipped with five hundred yards of pontoon material, and the personnel consisted of one hundred sappers, with N.C.O.'s, etc. additional. Two of the bridging trains were known as "Mobile Bridging Trains" and were fully equipped with land transport; the other two were towed about by tugs supplied when necessary. There were no Pontoon Parks.

(*b*) These bridging trains were self-contained. The personnel was sufficient for construction or dismantling of a bridge, and for its maintenance—including forming large cuts at frequent intervals, and safeguarding the bridge in storms and floods. On certain occasions, to ensure rapid work, the personnel was supplemented by that of Field Companies.

(*c*) To get out anchors quickly in the strong current and for help in various other ways, each bridging train had two motor launches. In the Mobile Bridging Trains these were carried on specially fitted Indian pattern pontoon wagons drawn by siege train bullocks. In the first instance these motor boats were heavily armoured, but the armour was rapidly discarded to reduce weight on both land and water.

4. Turning to the pontoons themselves, which really prompted this article, a different construction in both shape and material would have met the conditions better.

(*a*) Their bow resistance was too great for the very strong currents. The bows were occasionally drawn clean under and the belaying cleat of the anchor cable sometimes gave way. A semi-scow bow with parallel sides would have been better.

(*b*) Their material was not durable enough, and a well constructed steel pontoon would have had many advantages. But it would also have had its disadvantages. Owing to various causes replacements were difficult to obtain: after a serious smash wooden pontoons could nearly always be recovered and soon used: steel pontoons would never have been seen again—the depth was often over fifty feet. Similarly, damage from enemy fire was speedily patched.

(*c*) A completely decked-in pontoon would have been a great boon, but the decking should be removable to enable the pontoons to be used as open boats for ferrying purposes, particularly when forcing the passage of a broad river. In Mesopotamia some of the advantages of a decked-in pontoon were obtained by the use of two removable 6 ft. 6 in. by 6 ft. 6 in. tarpaulins fixed on the bow and stern of each pontoon by a light bamboo and wire framework.

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5. Certain other additions were made to the equipment.

(*a*) The absence of a handrail was a difficulty in a country where no local supplies of any sort exist, particularly in view of the great length of the bridges. One was improvised and adopted formed of oars and anchor cables. An iron hoop was fixed on the kelson of each half pontoon so as to come practically under the ribands when in bridge. The handles of two oars, fitted into each hoop, and the oars inclining outwards were attached to the ribands by the racklashings nearest the saddlebeam. The cable was fixed to each oar by a clove hitch at a height of about three feet. While affording no screen from view and little material support, this arrangement gave just the requisite moral support to the drivers, and prevented them getting the wind up, which was usually the cause of accidents, particularly in rough weather. It is considered that something similar should form a definite part of the equipment.

(*b*) When a continuous stream of traffic was using a bridge, the racklashings were occasionally cut by the steel tyre of a wheel; a following wheel forced its way through the joint of the ribands and over the edge. To guard against this without interrupting the stream of traffic, a small rectangular collar fitted to slip over the riband joint and made of ordinary bale hooping was introduced and found effective.

(*c*) Trouble was also experienced with the tendency of baulks to turn partly over out of the vertical under heavy traffic particularly in rough weather. This led to breakages and interruptions in the traffic. To guard against it, a "button chess" was introduced in the centre of each bay and proved effective. It consisted of an ordinary chess with 2-in. battens fitted across underneath so as to fit over the baulks and hold them vertical.

(*d*) To enable armoured cars to use the bridge freely seven baulks per bay were carried and put into bridge on original construction.

(*e*) To meet the rough weather conditions diagonal bracing under the roadway and direct bracing between bows and sterns of adjacent pontoons was found essential, and further was of considerable assistance in forming up in a strong current with a bottom giving treacherous hold to anchors. Breastlines were carried accordingly ready fixed on each pontoon.

(*f*) Another point was the large reserve of anchors and cable necessary. A firm hold against floods could often only be obtained by allowing anchors to sink in the mud to such an extent that it was impossible to recover them—even with steam winches. The top layers of mud—and any anchors in them—were carried away by a sudden flood.

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(*g*) All ranks were supplied with lifebelts for wear in very rough weather or other emergencies.

6. Modifications were also introduced in the method of carrying the equipment.

(*a*) In the first instance, for various reasons which need not be gone into here, but of which the absence of roads was one, pontoons were carried in separate halves on two-wheeled carts—the ordinary Indian A.T. cart, provided with a long axle to admit the pontoon between the wheels. The superstructure was then carried on G.S. wagons, which would be well suited for the purpose if only somewhat stronger. The pontoon cart gave a light load, but an awkward one, owing to the difficulty of balance and the extremely wide wheel track. This combination resulted in vehicles suitable for transport of supplies.

(*b*) Later the ordinary pontoon wagon was brought into use, but certain modifications were found necessary and quickly introduced. The fore carriage is weak and one particular member was always breaking and was replaced by a bigger piece. But its chief drawback was its unsuitability for ordinary transport purposes. To meet this, the chess-well was given a flooring of three movable chesses supported in their centre, wooden sides were fixed to it and movable endpieces. The front part of the wagon was floored with open work hoop iron and provided with angle iron side rails, and a movable front piece was fitted. The arrangement was designed not to interfere in any way with the proper use of the wagon for bridging material and to add a minimum of additional weight, but to admit of ordinary common supply loads being handled at any time without any further special preparations.

7. Detailed drawings of all these various alterations to pontoon, superstructure, and wagon, were made at the time and should be available in India, but may not have reached this country.

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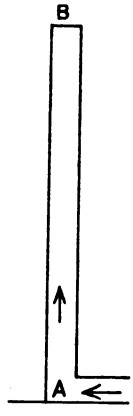
NOTES ON THE DESIGN OF TALL CHIMNEYS AND THEIR FOUNDATIONS.

By LIEUT.-COLONEL J. M. WADE, B.Sc. (London).

HAVING had experience in the construction of tall chimneys, and having known of instances of serious mishap owing to subsidence of foundations, I write these notes in the hope of giving useful information.

HEIGHT.—The height and internal dimensions will generally be fixed by the authority requiring a chimney, but should it be necessary for a Royal Engineer officer to settle these details, the information contained in these notes will enable him to do so. Draught is the pressure causing flow, the following is the physical explanation of the reason why there is a current of air up a chimney.



AB represents a chimney, inside the shaft of which the products of combustion are at a higher temperature than the external air, and being able to expand will do so; the density of the column of gases inside the chimney is therefore less than that of the air, and the weight of the column consequently also less. The pressure therefore at level A is also less than the external pressure at that level, and the outside air being able to enter will do so through the furnace, causing a flow up the chimney. An average sample of coal produces about 95,000 cub. ft. of CO and CO_2 per ton and requires about 300 cub. ft. of air per lb. for combustion.

According to these data the discharge from the chimney will be

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700,000 cub. ft. of air and gases for every ton of fuel consumed, the volume being calculated at the temperature of 60° Fahrenheit (*vide* Appendix 1).

Much useful information on the draught of chimneys is contained in a treatise on *Tall Chimney Construction* by R. J. Bancroft, Past President of the Institutions of Civil and Mechanical Engineers, from which the following formulæ have been extracted.

In these formulæ the symbols have the following meanings :—

t is the temperature of the air in degrees Fahrenheit ;

T is the temperature of the heated air inside the chimney, stated to be generally 580° at or near the summit ;

d is the density of the heated air inside the shaft, that is, the weight of 1 cub. ft. of air at temperature T° ;

D = ·0765 lb = weight of a cubic foot of air at temperature 60° Fahrenheit, barometer 30 in., the average temperature and pressure of the external air ;

H is the head of the external air in ft., which is defined to be the difference between the height of the chimney and that of a column of the external air, which at the temperature inside the shaft would fill it ;

h is the height of the chimney in ft. ;

v is the theoretical velocity of cold air entering the furnaces in ft. per second ;

V is the theoretical velocity of hot air at the summit ;

W is the theoretical draught of the shaft in inches of water.

Then

Volume of gases at temp. T° = Vol. at $t° \times (459+T)/(459+t)$

$d = D \times (459+t)/(459+T)$

$H = (D-d) \times h/D = h(T-t)/(459+T)$

$v = \sqrt{2gH} = 8\sqrt{H}$

$V = 2v$ on the assumption that velocity is proportional to volume and that the volume of air entering the furnace is doubled when it reaches the shaft.

$W = 12H/817$

The above formulæ are merely a simple application of elementary physical laws.

The actual velocity is in Bancroft's treatise stated to be generally $\frac{3}{4}$ of the theoretical velocity.

The relation between V and v is based on the assumption that the volume of air entering the furnaces has doubled by the time it has reached the shaft, and this will very nearly be the case if the external and internal temperatures are 60° and 580° F. respectively, but since velocity is proportional to volume the calculation of V for other conditions is not of any difficulty. A specimen calculation for the internal dimensions of a chimney is given in Appendix 2.

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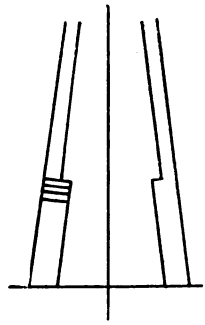
DESIGN.—Chimneys are usually built of brickwork but occasionally of iron or concrete.

At the summit the walling should not be less than one brick thick, and at every 20 ft. below the top it is usual to increase the thickness by half a brick exclusive of any firebrick-work, but this rule is only applicable to shafts of moderate height and internal diameter, say 150 ft. height and 4 ft. diameter. A table is given (*vide* Appendix 3) showing the particulars of some existing shafts as described in Bancroft's treatise already referred to. The face batter is usually one in 48, but should not be steeper than one in 60, and the planes of the courses are invariably arranged so that they are perpendicular to the face, the walls leaning inwards as shown on an exaggerated scale in the *Sketch.*



The horizontal section of chimneys may be square, hexagonal, octagonal or circular. The shaft is built from a base often square in plan, the design of the base is governed by the arrangement of furnace flues and by the question of stability, a system of dampers is necessary to regulate the draught, and a manhole at the base of the chimney is necessary for examination purposes.

A firebrick core half a brick thick at least is necessary at the lower portion of the chimney, and this core is never bonded into the walls of the chimney, but is built separated from them by an air space, so as to admit of free expansion under the high temperature obtaining at the base of the shaft. (Particulars of the cores of some existing chimneys are given in Appendix 3).

It is advisable when building a tall chimney to fix a light iron ladder outside from base to summit so as to admit of subsequent examination and repairs, and for the same reason an iron pulley should be fixed at the top, clear of the cornice.

CALCULATIONS.—The calculations necessary to secure stability are amply dealt with in *Notes on Masonry Structures* from which I have extracted the following brief outline to make this article more complete.

Considering the stability of a chimney supposed to be symmetrical with respect to a vertical ID, about a horizontal joint AB, the

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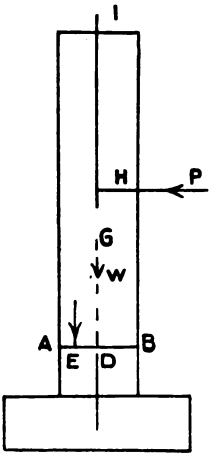
forces acting are (*a*) the horizontal wind-pressures, the resultant of which passes through H, the centre of inertia of the portion of the structure above AB considered as a thin shell.

(The point H may be considered without much error to lie midway between AB and the summit.) (*b*) the weight W of the structure which may be supposed concentrated at G, the centre of inertia which of course lies in ID.



(*c*) The upward pressures along the joint AB.

The effect of P is to tend to overturn the chimney about A and to shift the resultant vertical pressure, which of course is W, and which would pass through D, the centre of the base if there were no wind, to a point E, the distance DE which is termed the excentricity, and which will be denoted by *e*, is given by the formula—

e = M, the moment of P about A ÷ W .....(1).

The displacement of the line of action of the resultant vertical force to an excentric position causes an unequal distribution of pressure over the joint AB, the minimum intensity being of course on the windward side, and it is explained in *Notes on Masonry Structures* that, if the distance DE exceeds a certain maximum denoted by e_c the edge of the joint on the windward side will be in tension, which of course is inadmissible, if DE is exactly equal to e_c, the stress is zero at the edge on the windward side.

An essential condition therefore is that the ratio of $e : e_c$ should be less than unity. The formula for e_c is as under—

e_c = I ÷ (Area of section × y) .....(2).

Where I is the moment of inertia about a horizontal axis through the centre of inertia parallel to the edge of the joint and y is the distance from the centre of inertia to the edge ; thus, in the case of a hexagonal section, if AB were considered the edge, I would be

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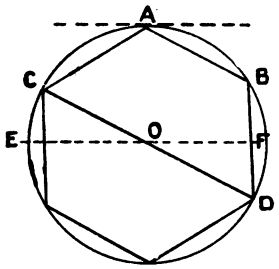
calculated about CD and the distance y would be the perpendicular from O to AB; if, however, it were considered necessary to consider the stability about the point A, then the axis would be EF, the parallel to the tangent at A to the circumcircle, and the distance y would be OA.



The necessary and sufficient conditions for stability are:—

(i) The excentricity e as already defined must be less than e_c; this condition ensures that the resultant of P and W will fall sufficiently within the base.

(ii) That the maximum intensity of pressure is less than that which the material can safely bear.

(iii) That the structure will not slide.

The maximum and minimum intensities of pressure are given by the formulæ:—

Y maximum intensity = Mean intensity $\times (I+\rho)$ .....(3).

X minimum intensity = Mean intensity $\times (I-\rho)$ .....(4).

Where ρ is the ratio $e : e_c$.

For sliding not to occur, P÷W must be less than μ the coefficient of friction, but as it is usual to introduce a factor of safety, 2, the condition for non-sliding may be written:—

P÷W must be less than $\mu/2$ .....(5).

For the complete investigation of stability it will therefore be necessary to compute and tabulate the values of P, W, the moment M, the excentricity e, e_c, the ratio of $e : e_c$, the weight W, the mean pressure and the values of X and Y at foundation level and at every level at which there is an essential change of shape. In *Notes on Masonry Structures* the wind pressure in lbs. is stated to be as under (*see* p. 39).

Square shaft of length of side b, $30 \times b \times h$;
Circular shaft of diameter d, $20 \times d \times h$;
Octagonal shaft diameter of circumcircle d, $21{\cdot}5 \times d \times h$;
Hexagonal shaft diameter of circumcircle d, $22{\cdot}5 \times d \times h$;
Where h is the height.

In the above formulæ the direction of the wind is supposed to be normal to one face.

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It will be found that a chimney designed according to the rules laid down, that is to say, with walls one brick thick at the top, battered at one in 48, will probably be stable at the ground level and higher, but if this is not the case the necessary adjustment of dimensions is not a matter of difficulty. The design above ground having been settled the question then arises how wide and how deep must the portion below the ground be. The course to follow is to assume a set of trial dimensions, and investigate the stability according to the rules given.

In all treatises on construction the necessity of arranging the design so that the resultant pressure is near the centre of inertia of the base area at foundation level is very rightly emphasized, but this is often difficult and it may be impossible without abnormal foundations, to avoid a considerable difference between the maximum and minimum pressure intensities on the ground below the concrete. Now a pressure of two tons per square foot may be a perfectly safe pressure to apply uniformly over the whole area, but it by no means follows that there might not be appreciable unequal subsidence if the pressure were two tons per square foot at one end of the base, diminishing to one ton per square foot at the other. In such a case practical experiments of the nature described on p. 77 of *Masonry Structures* to determine the bearing power of the soil should be made and, should the experiments show a material inequality of subsidence under the maximum and minimum pressure intensities, the question of piling the area will be a matter for serious consideration, but the design of the foundations in this eventuality is outside the scope of these notes.

The term "safe intensity of pressure," when applied to a rigid joint has a quite definite meaning, but when applied to an earthen foundation it merely means that the subsidence is uniform and not very considerable so long as the pressure intensity is less than a certain limit. Misapprehension on this point can lead to serious mishap. I have had occasion to examine many tall chimney shafts, and I cannot recollect a case in which some deviation from the perpendicular was not noticeable.

PRACTICAL DETAILS.—To ensure the perpendicularity of a shaft special arrangements are necessary, as the average bricklayer is quite unable to build a shaft in plumb if left to himself. The following method will be found to answer:—

The base of the chimney having been marked out, a template should be made of the exterior shape of the chimney five or six feet above the base level and securely fixed in that position in space at which its shape is coincident with that of the chimney, by stretching strings between the corners of the template and those of the base. The bricklayers will have lines to work on and can scarcely go wrong.

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When the template has been built up to, the process should be repeated until completion.

STRAIGHTENING SHAFTS.—It occasionally happens that a chimney tilts so much owing to unequal settlement that its stability is endangered.

It can be straightened by cutting out in one or more places about five courses of brickwork a little more than half-way round and on the side opposite to the direction in which the structure is leaning.

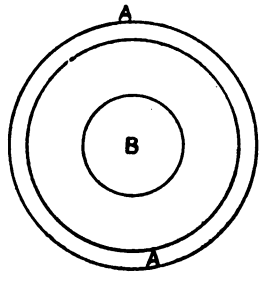
As the brickwork is cut out, short powerful screw-jacks are inserted until the jacks have taken a little more than half the weight, when they are screwed down until the shaft is straightened. When perpendicularity has been attained, the jacks are taken out one by one and the portion hollowed out is refilled with new brickwork.

When the deviation from the perpendicular is but small, it is often sufficient to cut out a single course halfway round the chimney at suitable levels, and to refill the gap with bricks of a slightly lesser thickness; as the old bricks are cut out the new ones are laid, care being taken to keep the gap as small as possible. Of course, the further this is done from the top, the greater the effect on the tilt.

I have tried the second of these methods on two occasions.

Several interesting operations in connection with the straightening of chimneys are described in Bancroft's treatise; both the methods mentioned are described therein.

INSTANCE OF MISHAP.—Among the mishaps which occur, those which are due to the subsidence of foundations are perhaps the most common. I will now give an instance of some interest. No R.E. officer was responsible. The structure concerned was the brickwork base for the support of a circular iron reservoir. After the lapse of 23 years I cannot give dimensions, but the size was quite abnormal and the height of the brick base was about 40 ft. The base was of a pattern often adopted for such structures. It consisted of a circular wall A A with numerous openings in it and a circular stem B, the space between A A and B being arched overwith a massive semi-circular arch.



In calculating the foundations it had been assumed that half the weight of the arch plus reservoir would be borne by A A, and half

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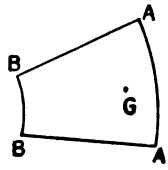
by B. Shortly after the base had been completed, and just after the bottom plating of the reservoir had been laid, a crack developed right round at the crown of the arch connecting A A and B, and examination showed that the crack was due to the outer periphery having settled more than the central stem. It is obvious that this is only what might be expected under the circumstances, for consider a slab such as A A B B, then G, the centre of inertia being much nearer to A A than to B B, the total load on A A is greater than that on B B and not the same as had been allowed in the calculations.



The injury in this case, though serious, was not irreparable, and an equal settlement was, I believe, obtained by temporarily loading over the stem B.

CHURCH SPIRES.—It occasionally happens, as, for example, in churches, that a spire or tower forms part of a structure; the problem of the foundations in such a case is nearly the same as for a chimney, but there is this difference: that whereas the latter is never bonded into adjacent walls, a spire must of necessity be an integral part of the structure to which it belongs.

In such a case the foundations of the spire will need very careful consideration if cracks in the adjacent walls are to be avoided, which, though not endangering their stability, are unsightly, and discreditable to the designer. In all probability in a case such as this the foundations of the spire or tower, in order to obtain the bearing area would probably have to be considerably deeper than those of the remainder of the structure, and, should a test be made, it would probably be found that the deeper foundation has the greater bearing capacity.

It must be remembered that the soil at any level has been subject during an immense period of time to an intensity of pressure greater than that at a higher level by an amount equal to the weight of a column of earth, the height of which is equal to the difference between the two levels. In the case of structures the foundations of which are at widely different depths, allowance should, I think, be made for the difference of level.

I mention this point as I know one very able officer of exceptionally wide and varied experience who holds a contrary opinion.

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Appendix 1.—Calculations of Gases Formed by the Combustion of one ton of Coal.

The changes occurring in the furnace are exceedingly complex, but ultimately the greater part of the carbon in the coal becomes CO and CO_2, the relative proportions depending on the completeness of the combustion.

Assuming that the coal contains 90 , 5 , 5 proportions by weight of carbon, nitrogen and oxygen, and that the chemical change is represented by

$$63C \times 3N \times 21H_2 \times 65O_2 = 40CO_2 \times 23CO \times 3NO_2 \times 21H_2O,$$

95,300 cub. ft. of gases would be produced, the temperature being reckoned as 60° F. per ton of fuel burnt.

To supply the necessary quantity of oxygen a considerable quantity of air will have to enter the furnace. In Bancroft's treatise, p. 28, it is stated that 300 cub. ft. of air are required, temp. 60°, for the combustion of every pound of fuel.

The chemical equation above given necessitates 71,000 cub. ft. of oxygen, temp. 60°.

Hence in the burning of one ton of coal 2,240 × 300 + 95,300 — 71,000 cub. ft. of gases will have to leave the chimney, or 700,000 cub. ft. in round numbers, this volume being calculated for a temperature of 60° F. In the equation above NO_2 has been entered to account for the nitrogen, but I do not think it likely that this gas (nitrogen peroxide) would be formed, but this is a point of no importance.

When temperatures are stated it does not necessarily mean that the gases are at the stated temperature, but as the volume of a gas varies with the temperature, whenever a volume is stated the temperature at which the volume was calculated must also be given. The volume V at temperature T really means the volume is V on the assumption that the temperature is T.

Appendix 2.—Calculations for Height and Outlet of a Chimney for Furnaces Consuming Two Tons of Fuel per Hour

Vol. of gases at temp. 60° is 2 × 700,000 cub. ft.
,, ,, ,, 580° is 2 × 2 × 700,000 cub. ft. nearly
= 2,800,000 cub. ft.

∴ as this is the discharge per hour the efflux per second will be

$$\frac{2,800,000}{3,600} \text{ cub. ft.}$$
= 780 cub. ft. nearly.

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If the outlet is 3 × 3, 4 × 4, etc., the velocity of efflux will be :

Section 3 × 3 ... velocity 87 ft. per second.
,, 4 × 4 ... ,, 49 ,, ,, ,,
,, 5 × 5 ... ,, 32 ,, ,, ,,
temperature assumed as 580° F.

With heights of 50 ft., 60 ft., etc., the theoretical velocity at the outlet is :

Height	50	ft.	...	velocity	81	ft. per sec.	
,,	60	,,	...	,,	88	,,	,,
,,	70	,,	...	,,	95	,,	,,
,,	80	,,	...	,,	102	,,	,,
,,	90	,,	...	,,	108	,,	,,
,,	100	,,	...	,,	113	,,	,,
,,	120	,,	...	,,	124	,,	,,
,,	150	,,	...	,,	139	,,	,,
,,	175	,,	...	,,	150	,,	,,

and as the actual velocity is in practice about one-third of the theoretical velocity it follows that a shaft 4 × 4 at the top and 175 ft. high would suffice.

In Bancroft's treatise, p. 29, it is stated that many existing chimney shafts are larger than is necessary.

Two tons of coal an hour is a very heavy coal consumption, but I have purposely chosen an extreme case.

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Appendix 3. PARTICULARS OF EXISTING SHAFTS

	Shape.	Height ground to summit.	Depth of foundations.	External dia. summit.	External dia. base.	Thickness at summit	Thickness at base.	Foundation area.	Height of internal core.	Thickness of core.	Remarks.
Townsend's Chimney, Glasgow	cir.	454′	14′	13′4″	32′	1′2″	5′7″	50′dia.	60′	9″	
Tennant's Chimney, Glasgow ..	cir.	435′	20′	13′6″	40′	1′2″	2′8″	50′dia.	243′	14″ to 22½″	
Wesenfeld's Chimney, *Barmen, Prussia	oct.	331′	—	11′	20′ × 20′	1′6″	5′3″	—	—	—	Square and 20′ × 20′ to a height of 40′ above octagonal.
Edinburgh Gasworks	cir.	329′	11½′	14′6″	26′3″	15″	3′	40½′ sq.	90′	20″ to 35″	The diameter of 26′3″ is at a height of 65′. The base is 30′ square up to this height. The thickness of core includes fire-brick 4½″ to 9″
Chimney at Brooks & Son's Works, Huddersfield	cir.	315′	15′	12′	20′4″	1′6″	3′2″	36′ sq.	150′	—	The diameter of 20′4″ is at a height of 70½′ above ground, the thickness of 3′2″ is at this level, below the shape is octagonal, increasing to 27′ diameter at ground.
Chimney, Adam's Soap Works, Birmingham	cir.	312′	15′	5½′	27′2″	9″	—	—	—	—	
Chimney, Dean Clough Mills, Halifax..	oct.	300′	—	15½′	30′	3½′	—	32′ dia.	—	14″	Built of stone and founded on rock. Inside diameter of base is said to be 9′.
Chimney, Johnson & Co., Greenhithe	cir.	297′	7′	11′	25′	1′1½″	3′9″	30′ sq.	no	core.	At the ground line external shape is square to a height of 41′.
Chimney, Merrimac Co. Works, Lowell, U.S.A.	cir.	282′	—	14′	28′	12″	24″	—	280′	4″ to 16″	This chimney has 2 cores, the first inner shaft the walling of which is 8″ thick extends up to 75½′ where it is merged in the outer shaft; innermost shaft is 12′ diameter throughout, 280′ high, 16″ to 4″ thick.
Chimney, Works of Storey Bros., Lancaster	oct.	250′	20′	10′8″	25′	9″	4½′	28′ sq.	250′	4″ to 16″	
Chimney, Fox & Co. Works, Sheffield	oct.	186′	15′	8′1″	14′9″	1′2″	—	19′3″ sq.	90′	9″	The internal diameter at ground line is said to be 5′9″, allowing 2′ for fire-brick core including cavity the thickness of walls at ground level would be 3½′.

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PROFESSIONAL NOTES.

ERECTION OF STEEL TOWER AT YANTLET

(CONTRIBUTED BY THE DIRECTOR OF FORTIFICATIONS AND WORKS.)

A BRACED steel tower, 210 ft. high, manufactured to designs prepared in the War Office by Messrs. Braithwaite & Co., Constructional Engineers, West Bromwich, was raised from the horizontal to a vertical position and anchored to its foundation on July 21st, 1921, by the same firm.

The tower weighed about 50 tons ; its base was 14 ft. 6 in. square and its top 4 ft. square.

The hoisting arrangement consisted of two 100-ft. steel derricks, each secured by eight guy-ropes. A set of four- and three-sheave pulley blocks was fixed to each derrick, and 2½-in. steel ropes ran from these tackles to two steam winches, the tension in the ropes leading to the winches being about 4 tons.

The pulley blocks were attached to the ends of a trunnion, fixed with temporary reinforcement just above the centre of gravity of the tower. Two rollers running in channel racers on a temporary staging were fixed to the base of the tower, the load on these when the tower was horizontal and the weight taken on the tackles being 2½ tons.

Lifting commenced at 1.33 p.m. ; the tower was at an angle of 45 degrees by 2.10 p.m. and was resting vertical on its foundation by 3.10 p.m.

The foundation consisted of a block of reinforced concrete weighing about 140 tons and resting on ten 14-in. reinforced concrete piles. The tower was anchored down by four 2¼-in. steel bolts, each 5 ft. long. The ground is very marshy and low-lying.

There are three guy-ropes to the tower, one 4-in. anchored to a block of about 15 tons of concrete, and two 3-in. anchored to 9-ton blocks. There is a permanent strain in one direction, rendering a fourth guy-rope unnecessary.

Photographs of the erection are given.

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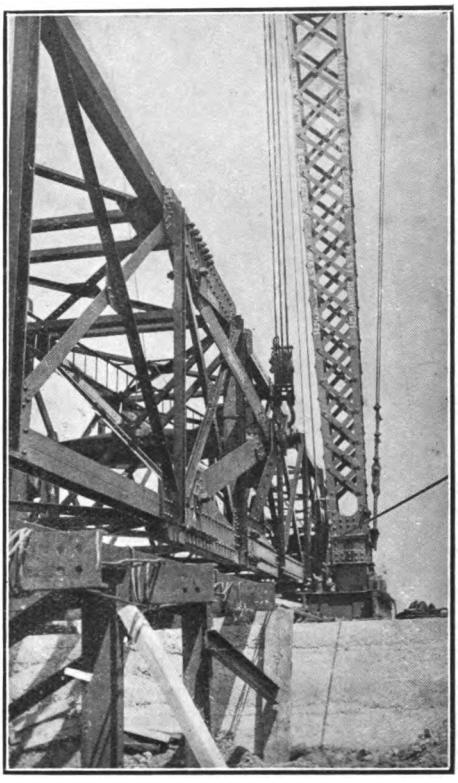
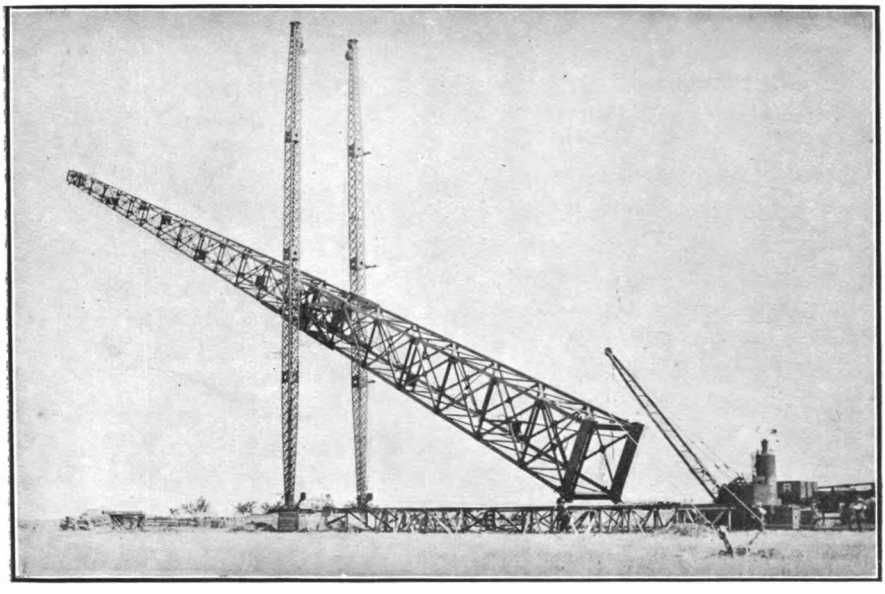
ERECTION OF STEEL TOWER AT YANTLET.





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NOTES ON REFRIGERATION.

(With Special Reference to the Ammonia Compression System).

By CAPT. L. C. REID, M.C., R.E.

GENERAL PRINCIPLE.

The operation of refrigerating machinery is best described as the opposite of the steam-engine cycle—namely: the conversion of work into heat in such a way as eventually to produce low temperatures.

DIFFERENT METHODS OF PRODUCING COLD.

These fall, roughly, under the following heads:—

(*a*) Frigorative Mixtures.
(*b*) Air-Machines.
(*c*) Evaporation under vacuum.
(*d*) Machines using a material which is alternately vaporized and condensed:—
  (1) By heat direct—Absorption Machines.
  (2) By work done on it—Compression Machines.

(*a*) *Frigorative Mixtures.*—When certain solid substances, such as ice and salt are mixed they tend to combine and form a liquid. To produce liquefaction the latent heat of fusion has to be absorbed and as this cannot be supplied from external sources quickly enough, the temperature of the mixture falls.

This principle is not applied commercially on a large scale but is used in small "sweet ice" making machines.

(*b*) *Air Refrigerating Machines.*—In this system air at a low temperature is used as the medium for cooling. It is drawn from the cold room into the compressor, compressed and delivered at a higher temperature to a condenser where it is cooled. The cool air is then admitted into an expansion cylinder where it does work in expanding by assisting the engine to overcome the compression stroke, and consequently the air loses heat. It is then returned to the cold room. Air-machines are large and of low efficiency compared with the ammonia and other compression types which are now more generally used.

(*c*) *Evaporation under Vacuum.*—This depends on the principle that water evaporates more freely as pressure is reduced. The heat required to produce evaporation will be obtained from the water itself unless it can be got as quickly as required from other sources.

The water to be frozen is put under an air-pump and the vapour, as it is formed, is absorbed by sulphuric acid.

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In order to obtain ice it is necessary to maintain a very high vacuum as water at 0° C. has a vapour tension of only 4·6 mm. and the renewing of the acid is troublesome. The system is used on but a small scale.

(*d*) (1) *Absorption Machines.*—A strongly concentrated solution of ammonia in water is heated by steam coils in a still. Ammonia is driven off in the form of vapour under pressure and passes to a condenser in which it is cooled and liquefies, afterwards being allowed to expand in refrigerating coils, extracting heat from the brine or water surrounding the coils. It then passes to the absorber, where it is absorbed by the weak ammonia liquid drawn from the lower part of the still. This liquor, strengthened by the ammonia absorbed, is pumped back to the still, passing through an exchanger in which it takes up heat from the hot weak liquor on its way to the absorber.

This process is used to some extent, although the Compression system is from 2½ to 3 times more efficient. There are practically no moving parts, the plant requires very little attention, and, where low pressure steam is available the system has its advantages.

(*d*) (2) *Compression Machines.*—In this system a gas, or rather saturated vapour, is used in a closed system of piping. This vapour is drawn into a compressor and subjected to such a pressure that when it is passed through a condenser it liquefies. This liquid is then allowed to pass through a regulating valve to the refrigerating coils where it vaporizes under the reduced pressure caused by the return stroke of the compressor. In order to vaporize it has to absorb the necessary latent heat units from the medium surrounding the refrigerating coils, which is consequently cooled.

COMPARISON OF AMMONIA AND CARBON DIOXIDE.

In a large majority of refrigerating plants the vapour used is either ammonia or carbon dioxide. The table below gives a comparison of the properties of these vapours.

	Ammonia.	Carbon Dioxide.
Absolute pressure at 0°F. in lbs. per square inch	30·4	310
,, ,, ,, 85°F. ,, ,, ,, ,,	167·8	1068
Heat of vaporization in B.T.U.S. per lb. at 0°F.	555·5	123·2
Volume of 1 lb. in cubic feet at 0°F.	9·04	0·277
Heat of vaporization per cubic foot	61·7	447
Critical temperature F.°	266°	88°
Relative sizes of Compressors for theoretically equal refrigeration	7·2	1
Loss due to cooling of liquid from Condenser temperature	·18%	·80%

From this it will be seen that for equal effects a CO_2 machine can

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be considerably the smaller and is therefore largely used on ships. On land, however, the ammonia machine is generally preferred, due, firstly, to much lower working pressures; secondly, to less loss in cooling of liquid; thirdly, to greater refrigerating effect per lb.; fourthly, to working quite efficiently when condenser temperature is high, owing to lack of water or hot climate. As the critical temperature of CO_2 is 88°F., the efficiency falls off at higher temperatures.

Owing to improvements in manufacture the danger of using poisonous ammonia in large quantities has been overcome and its pungent smell gives it an advantage over CO_2, as leaks are easily detected.

Ammonia Compression Plant.

This consists essentially of two parts :—

(*a*) High Pressure side—machinery for liquefaction;

(*b*) Low Pressure side—evaporation of liquid.

Dealing with the high-pressure side there is first the compressor. This is usually on the horizontal double-acting type with self-operating valves and in consequence it only runs at low speeds—70 to 90 revolutions per minute. A new type is now being tried, fitted with a special type of disc valve and it is hoped to run this at 200 revolutions per minute. If successful and efficient, this will admit of much smaller compressors being used for a given refrigerating effect.

Before the vapour is drawn into the compressor, it passes through a purifier on the suction side; this is duplicated so that the plant need not be out of action during cleaning. Quicklime is used to absorb any moisture that may get into the system.

On the delivery side the compressed vapour is passed through a special grease-filter which removes any oil that may come over from that used in the compressors for lubrication. This is very essential as, if oil is allowed to get into the condenser or refrigerating coils, a serious loss of efficiency will result. Special non-freezing oil must be used or the valves will gum up.

Cotton or metallic packings are used for the piston-rod, in lantern glands. Great care is required in tightening up these packings or the rod will become worn and air drawn in on the suction stroke.

The condenser is usually of the evaporative open-air type in which the vapour passes through a series of coils over which cold water is allowed to drip. Now the pressure here and at the delivery valve of the compressor is entirely fixed by the cooling which is possible by the condenser and corresponds to the pressure of saturated ammonia vapour at that temperature. The pressure, therefore, varies in summer and winter and in hot and cold climates.

The amount of cooling water must be sufficient to absorb the latent heat of vaporization and also any heat due to super-heating of the vapour.

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Cocks are provided on the top of the condenser coils for removing air from time to time, as circulating air gives practically no refrigerating effect.

Clearances in the compressor must be small, otherwise very little new vapour can be drawn in on the suction-stroke. In some machines this "dead" vapour, due to the clearances, is got rid of by injecting oil at each stroke and discharging the excess through the delivery-valves, but it is questionable if there is any gain by so doing, as it produces a loss of efficiency due to the oil-pump and further complications in the removal of the oil.

For safety, some makers fit spring cross-heads, cylinder-covers or piston-heads so as to prevent the cylinder-covers being fractured if liquid instead of vapour should be drawn into the compressor.

LOW-PRESSURE SIDE-REGULATING VALVE.

Liquid ammonia flows by gravity from a receiver placed below the condenser to the regulating-valve. The regulating-valve should be placed as near the refrigerating-coils as possible. On opening the valve (a specially constructed screw-down needle-valve) the liquid ammonia passes through into the refrigerating-coils. The pressure and the temperature fall and a portion of the liquid is evaporated. As the liquid ammonia flows through the coils, heat is received from the surrounding brine, or other medium to be cooled, and more liquid is evaporated. The resulting vapour is drawn back into the compressor.

Theoretically, the expansion-valve should be replaced by an expansion-cylinder and the liquid in expanding made to do work; thus less work would have to be done by the engine and more heat could be absorbed. This is never done in practice owing to the mechanical complications in design.

The regulation of the expansion-valve is important, as, if opened too much, liquid ammonia flows back into the compressor and may cause damage, besides lowering the efficiency due to non-vaporization.

The valve can be regulated so that the vapour at suction-side is so "wet" that after compression vapour is delivered just saturated, *i.e.*, the liquid present, in vaporizing, absorbs the heat of compression. The valve can be shut still further so that the vapour at the suction-side is practically dry, and full use is made of all its latent heat of liquefaction; the vapour will be very hot now on compression and useless work will be done.

When ammonia is used the efficiency remains approximately the same, whether or not the compressor is run superheated; a slightly less efficiency results from using a superheated system, but a greater refrigerating effect per lb of vapour circulating is obtained.

It is usual to compromise by running the compressor-cylinders

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water cooled and the valves so regulated that the delivery-pipe is hand-warm, when running normally. When it is desired to maintain a fixed temperature the compressor is run on full load with expansion-valve regulated to give the most efficient working. If the cooling effect is too great the compressor is stopped until the temperature rises and is then started again.

Ice making.—Owing to high freight charges less Norwegian ice is imported than formerly, and approximately some half million tons have to be made annually in this country. Ice making has therefore become quite a large industry. Good water must be used or bad ice will result ; this, besides having a " milky " white appearance, does not last any length of time. The opaqueness is caused partially by dissolved solids, but chiefly by the air in the water. In America distilled water is used, but in this country good town water is employed and de-aerated by mechanical means, such as compressed air, agitation and shaking of the cans, movement of paddles, pumping in water through jets, etc.

The four main systems of ice making are :—

(*a*) Can. (*c*) Plate.
(*b*) Cell. (*d*) Direct-expansion.

The Can System is the oldest and most generally used. The ice is formed in tapered galvanized iron cans or moulds, made in standard sizes, holding from one-half to two cwt. of water each, producing rectangular slabs of ice from 4 in. to 11 in. thick. The moulds are filled with water and immersed in a tank of brine cooled below 32°F. The cans, when the water is frozen, are lifted out and dipped in a tank of tepid water to loosen the ice, which is then tipped out. An eleven-inch can takes 60 hours to freeze.

It is necessary to agitate the water in the cans during freezing in order to produce clear ice.

The refrigerating-coils are usually in the brine tank itself and the brine circulated by means of a small centrifugal pump.

The Cell System.—The water to be frozen is put into a large tank which is divided into a number of " cells," or compartments, by hollow walls of cast or wrought iron. The tank is also fitted with a false bottom.

Brine is cooled in a separate tank containing the refrigerating-coils, and is pumped from this through the hollow walls, thus causing the water to freeze. The water is kept agitated by means of paddles and the false bottom up to the last minute, and so better ice is obtained than with the can system.

For thawing off, hot brine from another tank, heated by a steam-coil, is circulated until all the blocks are free to be lifted out by a crane. In spite of better insulation cell-ice takes longer to form ; a machine which can produce 1·1 tons of can-ice would produce

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only 0·9 tons of cell-ice in the same time. That is, cell-ice takes one-fifth longer than can-ice to form.

Plate System.—A large tank is divided by hollow walls in one direction only, through which walls cold brine is circulated. Ice is formed on both sides of the walls in large plates, and as it is formed outwards and removed before it has frozen solid across, very good ice is obtained without agitation, and all the impurities tend to remain in the water and can be drained off before the ice is withdrawn. It is usual to place against the walls metal plates on which the ice is formed. These are removed with the ice, which is slowly thawed off to prevent it cracking.

The best ice is made by this system, but it is much more expensive and slower than the other systems. Some ten days are taken to make a 12 in. slab.

Direct Expansion.—In this system the refrigerating-coils are placed directly in the water to be frozen.

The general principles of two direct-expansion systems are described below.

The Empire System is similar to the cell system. A large metal tank is divided into compartments by hollow metal walls. Sloping metal channels are riveted inside these hollow walls in such a way that the ammonia admitted at the top has to make a series of backward and forward paths before it can pass out at the bottom to the suction-pipe of the compressor.

The regulating-valve is placed right against the tank and not in the engine-room, as is generally done in other systems. Agitation is obtained by compressed air. The freezing is very rapid, but the quality of the ice suffers in consequence. The efficiency of the plant is increased by the absence of brine losses, but reduced owing to the working at lower temperatures.

The "Pluperfect" System has only been placed on the market recently, and promises to be the best and most efficient system.

Eight refrigerating-coils are fixed vertically and equally spaced in a wooden tank, 12 ft. by 10 ft. by 7 ft. Each set of coils consists of three groups of seven "bends," each 6 ft. 6 in. high. Each "bend" consists of two "D" section-tubes welded together and connected together at the top. The bottom of each "bend" is welded to the next so that a complete set of coils is formed.

When the regulating-valve is opened and the ammonia admitted the water begins to freeze, and as it expands the level is kept constant by providing an overflow at such a level that the top of the coils is just uncovered. Ice forms round the groups of bends and 24 blocks are made. Before the whole is frozen solid the regulating-valves are closed and by means of valves provided for the purpose liquid ammonia is passed through the coils for thawing off; the ammonia is not wasted but is passed through the regulating-valves of other

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tanks. As the top of the coils projects above the ice it is easy to see when thawing out is complete.

Hot water from the compressor-jackets is also passed through other pipes at the bottom of the tank to thaw off the under side of the blocks. To facilitate the lifting out of the block a special clip is placed on the top of coils before freezing commences, and is frozen into the block of ice.

This system produces clear solid ice and combines the advantages of the plate system in this respect with those of the can system as regards time of manufacture. Ten-inch ice is made in 41 hours without agitation. Another advantage is the ease of control, as freezing can be stopped and ice removed when required. Damaged coils can be cut out and the plant still worked. The replacement of coils can be carried out easily.

The ice formed has seven holes up the centre, but there is little disadvantage in this, as in most cases ice is crushed before use.

If agitation is required water is pumped through nozzles situated between the blocks, but with ordinary town water this is unnecessary, as clear ice is formed without agitation.

With compressors driven by gas-engines working on suction-gas, 25 tons of ice can be produced with one to one-and-a-half tons of anthracite coal. Taking water at 52°F., this gives an overall efficiency of

$$\frac{25 \times 162}{1{\cdot}5 \times 15{,}000} = 18\%.$$

In the cell system, working with steam plant, the production of ice may be as low as 5 tons of ice per ton of coal.

TYPICAL TEMPERATURES FOR CELL- AND CAN-ICE.

Temperature of water off condensing-coils: 57°F.
Gauge pressure of ammonia in condenser: 107 lbs. per sq. in.
Temperature: 65°F.
Suction-gauge temperature: Can, 14°F. Cell, 11°F.
Brine temperature: Can, 23°F. Cell, 21°F.

COLD STORAGE.

Besides ice making, refrigerating plant is used largely in the storage of meat and produce at a low temperature. Cold stores are specially constructed rooms, the walls, etc. being insulated with granulated cork and lag-wool, or other non-conducting material.

Some of the methods used for maintaining low temperature in the stores are:—

1. Circulation of cold brine in coils;
2. Circulation of cold air;
3. District expansion in coils.

1. *Brine Circulation.*—Brine is cooled in a separate cooler and is pumped through a series of coils fixed to the roof and walls of the

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chamber. The air, cooled by the coils, falls, and circulation is thus set up. Brine has a high specific heat and so provides a storage of "cold" which helps very materially to maintain a uniform temperature in the case of a temporary shut-down of the plant. This is a very suitable method of keeping materials just below 32°F., but it does not ensure a very good circulation of air.

2. *Cold Air.*—The air is drawn from the top of the cold chambers through ducts by a forced-draught fan and delivered through a battery of direct-expansion coils, in which it is cooled, back to the chambers through other ducts arranged to discharge downwards.

Brine is usually circulated over the expansion coils and special arrangements are provided for bringing the air into intimate contact with the cold brine. By this means the air is washed and any moisture in it is retained by the brine. As the brine solution becomes weaker by the absorption of moisture it is necessary to occasionally reconcentrate it in an evaporator.

Separate batteries may be used for each room, or one large battery only for the whole store when regulation of temperature is obtained by opening or closing the delivery-ducts in each room. The former method gives the better regulation but is expensive in installation and takes up more space.

Below are given typical temperatures at various points with this system :—

Ammonia delivery	... 65°F.	
Ammonia suction	...—5°F.	Diff. 8°.
Brine Solution	... 3°F.	
Air inlet (at fan)	... 23°F.	
Air outlet	... 8°F. (5° above brine).	
Rooms	... 22°—26°F.	

3. *Direct Expansion.*—In this system coils are placed directly in the cold chambers taking the place of the brine pipes referred to in (1). The system is more flexible but there is no reserve of "cold" as with the brine.

Snowing-up and Thawing-off.—When unfrozen or unchilled produce is placed in the chambers some of the moisture present evaporates into the air before the produce reaches a temperature of 32°F. As the air circulates over the refrigerating, or brine coils, as the case may be, this moisture is deposited in the form of snow on them. Even if only frozen produce is put into the stores snow still forms, due to "wet" air reaching the chambers from outside.

The efficiency of the system falls off considerably if snow is allowed to form to any great extent, as the coils are not so capable of taking up heat due to the poor conducting covering.

In system (2) snow causes little trouble. As there are no coils

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in the chambers no snow is deposited here; and the snow, which is formed, is absorbed by the strong brine circulating over the refrigerating-coils as fast as it is formed.

In systems (1) and (3), however, the snow forms in the chambers themselves and in consequence special arrangements have to be made to get rid of it from time to time. This entails passing hot brine or "hot ammonia" through the coils and collecting the melted snow in some suitable manner.

The method used in the new installation at the Royal Albert Dock is as follows:—The whole store is insulated very thoroughly on the outside walls, the ground floor and the roof, the intermediate floors and partitions are, however, all built with open-spaced planks so that there is free circulation of air throughout and the building consists essentially of one large room.

In the centre is a battery of some six sets of refrigerating coils. Warm air is drawn from the top of the building by electric fans, forced down over the coils, and led out through ducts on the ground floor. As the air becomes warm it rises and is then forced down over the coils again.

A collector connected to a drain is fixed under each set of coils. Hot liquid ammonia is passed through the coils as required for thawing off, any snow which has collected on them will melt and the water is drained away without trouble—the whole operation taking some twenty minutes.

This method appears very economical and simple, but of course cannot be applied when stores are used for keeping goods which have to be maintained at different temperatures.

Regulation of Temperatures in Cold Rooms.

The regulating-valves should in all cases be fitted as near as possible to the expansion-coils they control and not placed together in the engine-room, as is sometimes done.

Special thermometers are made in which the temperatures recorded can be transmitted to an indicator in the engine-room, and one of these should be fixed in each chamber.

The above merely touches the fringe of the subject and is of necessity incomplete. Further information could be gained by consulting one of the numerous books on the subject.

The following are suggested:—

Refrigeration, by Milton W. Arrowood; *Refrigeration, Cold Storage and Ice Making*, by A. J. Wallis-Taylor; *Refrigerating and Ice Making Pocket Book*, by A. J. Wallis-Taylor.

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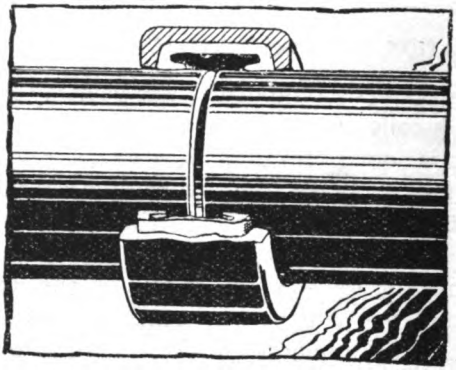
SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.

(CONTRIBUTED BY THE R.E. BOARD.)

THE following exhibits which appear to be of use to the military engineer, were noticed at the Shipping Exhibition at Olympia.

THE "VICTAULIC" LEAK-PROOF PIPE-JOINT.

This is a development of the hydraulic "U" washer which has been in general use for generations. The inner part of the joint—the leak-proof ring—amounts in effect to two opposed "U" washers, with the outer rings united but with the vital addition that the inturned lips are made to grip the pipe ends radially when the joint is pushed into position. The joint is proof against vacuum as well as pressure and may be flexed in any direction up to three degrees without leakage. It can be used with pipes conveying water, oil, steam, benzine or chemicals by the use of different types of leak-proof rings.



The "A" type (floating) joint used for low pressures or for buried or anchored pipes.

A second or "B" type form is made for special cases when pipes have to be secured against end displacement in which the locking ring or socket fits into grooves cut on the ends of the two pipes to be jointed.

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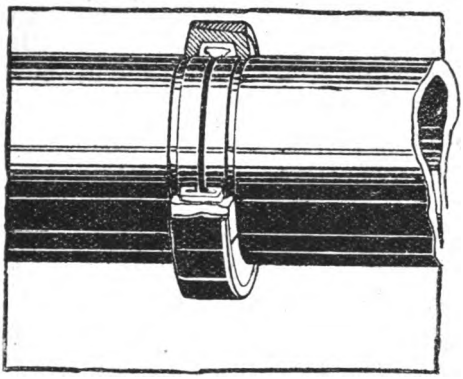

The "B" type (located) joint which secures the pipes positively against end displacement under pressure.

A Combined Chain Helice Lift and Gear Force Pump.

The Boulton pump (by Boulton & Paul, of Norwich) is suitable for any depth down to 150 ft. and forces up to 100 ft. The pump can be obtained petrol-driven, electric motor-driven, or belt-driven.

The general dimensions are 30 in. by 14 in. in plan and the duty of the pump is 300 to 350 gallons per hour through a ¾-in. rising main. The force pump body forms part of the hood casing of the chain helice portion of the pump and is mounted on the same shaft. A loose circular weight is used to keep the chain taut.

The Turbo Cornelle Lift and Force Pump.

This pump is also made by Messrs. Boulton & Paul and is an extension of the canvas belt pump used in France. It will raise 5,500 gallons per hour 200 ft. and force an additional 80 ft.

The pump differs from the old canvas belt pump in having corrugated metal strips rivetted on to the outer side of a composite canvas belt.

These strips run about 1 in. wide and are close together, but the indentations line up across the belt to render it flexible. The general arrangement of the pump is similar to the Boulton pump described above.

Finney Pump.

These pumps are of the reciprocating piston type, and are double-acting. As will be seen by a glance at the sectional drawing reproduced below, a new principle has been introduced into reciprocating pumps by arranging the valves and also the discharge of all *below the cylinder*. It has been demonstrated that this arrangement adds considerably to the volumetric efficiency as compared with that of

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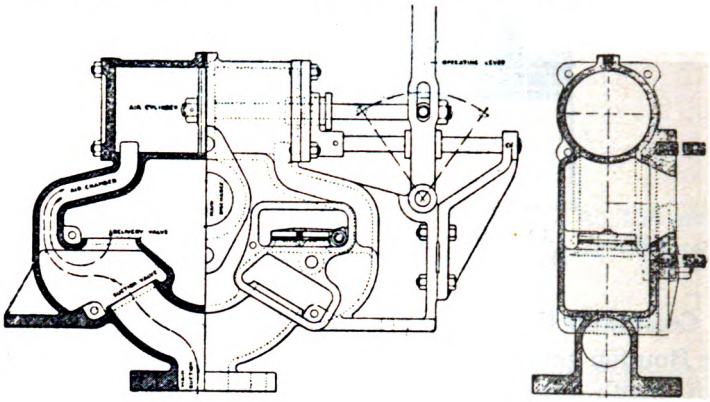
all other types of pumps, and has the further great advantage of securing a *dry cylinder* when the pump is operating within certain limits, thus effecting great economy in the life of the pump. It is, of course, more particularly desirable to preserve the dry cylinder when dealing with corrosive, gritty or heavy liquids.



PARTICULARS OF STANDARD HAND PUMPS.

1. No. of Pump.	2. Diam. of Suction and Discharge in Inches.	3. Quantity of Water in Gallons per Hour.	4. Limit of Vertical Section.	5. Dry Cylinder obtained at Suction of:— (see Footnote*)	6. Weight.
1	1	500	22 ft.	13 ft. 6 in.	28 lbs.
2 D	2	1,000	9 ft.	always dry	90 lbs.
2 E	2	1,500	23 ft.	18 ft.	73½ lbs.
3	3	—	—	—	—

* A dry cylinder is not obtained until the vertical suction reaches the figure quoted in column 5, but is then retained with any delivery head.

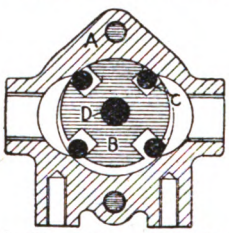
The capacities quoted in column 3 are those obtained on a 3-foot vertical suction.

A new design of 3-in. pump is being prepared to deal with heavy duties.

THE E.W. PUMP.

This little pump consists of a four-slotted disc with a loose roller in each slot rotating in an eccentric drum. It appears very suitable for cooling water services or for suds on machine tools. The No. 1 size giving 170 gallons at 1,200 revs. per minute is only 6 in. long, including the pulley. A sketch is attached.

"E (Eliminate)



A Housing. C Rollers.
B Rotor. D Shaft.

W" (Wear)

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Pumps for Oil or Water.

(Four models made : 2 for oil or suds, 2 for water, etc.)

Advantages.

1. The simplicity of principle and design gives utmost reliability and maximum life.

2. The Rotor " B " has four free rollers " C," which automatically take up what little wear occurs, so that when wear takes place the suction remains unimpaired, and capacity is only slightly reduced.

3. Runs equally well in either direction.

4. Does not get stopped up. The rollers, which are perfectly free, ride over any small obstruction which then is carried to the discharge.

5. Ideal for cooling water service and for suds on machine tools.

6. The smallest, lightest and cheapest pump for the output on the market.

The Silent Record Engine.

A two-cylindered sample of this engine was shown running. It is practically vibrationless, as a glass of water standing on the engine was practically free from ripples.

The engine is two-stroke and has a piston valve which admits air to a compressing chamber and then to a twin-coupled cylinder mounted on the top of the compressing chamber. The piston is made up of—

(i) twin firing pistons, a compressing piston and a trunk guide.

The twin firing pistons are so arranged that the exhaust port on the one cylinder opens before the end of the stroke. The inlet port on the other cylinder opens later and the compressed charge rushes up the one cylinder and down the other, and so scours the firing cylinders.

This engine is made in 14 sizes from 1½ b.h.p. to 225 b.h.p.

Rust Proofing by the Galeco Process.

The samples of work shown are interesting and it is claimed that this is superior to ordinary galvanizing, as the alloy deposited is not plain zinc but an alloy with a greater resistance to corrosion, which forms an absolutely contiguous coating without the uneven finish which generally is obtained with ordinary galvanizing.

A lustrous polish can be obtained or the finished article can be painted without the use of a mordant. The uses for which it is recommended by the Company include screws, bolt nuts, water pipes and fittings, pulleys, ironmongery, etc.

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NOTES ON ALDERSHOT–COLOGNE W/T SERVICE.

CONTRIBUTED BY THE R.E. BOARD.

THIS service was installed primarily for military telegraphic traffic and partly in order to provide a practical and prolonged trial of the High Speed W/T apparatus developed at the Signals Experimental Establishment at Woolwich.

The High Speed service was installed and operating in October, 1920—though brief experimental periods had been worked at a much earlier date.

From October, 1920, in addition to purely military traffic, the daily press news was regularly transmitted to Cologne for publication in the local English newspaper.

After working for some time a system of remote control was installed which enabled the W/T apparatus to be operated from a distance.

A demonstration of the capabilities of the system was given to representatives of the G.P.O. to enable them to form an opinion as to the value of the system and its possibilities in regard to relieving the wires of some of the commercial traffic. The P.O. authorities were sufficiently impressed to arrange for a trial for commercial working under their control. This trial began in February, 1921 and resulted in the G.P.O. commencing regular operation on 24th August last.

Since that date a varying number of words have been dealt with daily according to P.O. requirements, which, generally speaking, are not nearly sufficient to fully employ the station.

Certain hours in each day are allotted to the G.P.O., other hours being reserved for military traffic.

Urgent military messages have priority and may be transmitted at any time.

The High Speed Service normally works at 90 to 100 words per minute, but is capable of much greater speeds.

The Post Office traffic is transmitted from London by machine telegraph and reaches Aldershot by wire; it is there automatically transferred to wireless and is radiated. It is received at the wireless station outside Cologne and there automatically transferred to the German underground cable by which it is carried to the German Post Office in Cologne, where the messages are recorded on paper slip. The traffic in the reverse direction follows the same route, but is finally printed out in Roman characters in the Central Telegraph Office, London, practically simultaneously with its transmission from Cologne.

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The following approximate figures may be of interest:—
During September the traffic at the Aldershot end was:—

	Words sent.	Words received.
Civil traffic	41485	33971
Military traffic ...	15379	904
	56864	34875

The big predominance in the military working of words sent over those received is due to the daily transmission of the press news, which ranks as military traffic in this connection.

During this period the total cost of electric power to run the electrical machinery and also including lighting and heating the station amounted to just under £22, while the value of the traffic handled based on 3d. a word—the official telegraphic rate to Germany—comes out at a little over £700.

The best day for traffic recorded to date was 28th September, when the figures for civilian traffic were:—

Words sent	3390
Words received	1590
Total	4980

On this day the Post Office used the station for 5½ hours, but the traffic output might have been far greater.

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CORRESPONDENCE.

To the Editor of the R.E JOURNAL.

SIR,—In Lieut.-Colonel R. P. T. Hawkesley's article on "Water Supply to Armies in the Field," published in your September issue, he points out that "Tanks, waterproof, canvas, 2,300 gallons" and "Troughs, waterproof, canvas, 600 gallons" hold only about 1,500 and 350 gallons respectively and suggests that it would be interesting to ascertain how the registered contents were originally arrived at. May I offer the following as a possible solution?

The official in question (obviously not an R.E. officer) measured up the articles and found they would hold 230 and 60 cubic feet. He remembered vaguely that a gallon weighed 10 lbs. and that 6¼ went to the cubic foot—or was it the other way round? He tossed for it and fate decided that a cubic foot should contain 10 gallons. Had the coin fallen the other way he would have found the contents to be about 1,450 and 375 gallons, which are approximately the figures given by Lieut.-Colonel Hawkesley.

I am, Sir,
Yours faithfully,
J. S. BAINES, *Capt., R.E.*

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REVIEWS.

ECONOMICS OF BRIDGE BUILDING.

By J. A. L. WADDELL.

(Price, 36/-. Chapman & Hall, Ltd. 1921.)

This volume gives a summary from the economic point of view of the vast experience gained by the author during his life of bridge building in all its branches. It contains much useful data for comparing the probable costs of bridges of all known types and spans constructed in various materials, and gives the author's opinion as to the most economical way of carrying out the numerous operations involved during ship work, erection and subsequent maintenance. There is a chapter in general terms devoted to military bridging, where saving of time is usually of greater importance than reduction of cost. The book is perhaps more useful to those confronted with large bridging problems than to the military engineer, but is of undoubted value as being the final work of a bridge builder of exceptionally wide experience and world fame.

E.F.T.

LA PRISE DE CARENCY PAR LE PIC ET PAR LA MINE.

By CAPITAINE THOBIE (Paris, Berger-Levrault, 15 francs).

The author is an officer of Engineers and his book, which describes the capture of Carency in May, 1915, is of considerable engineer historical interest. Apart from the text, the 87 reproductions of photographs give an extraordinarily good idea of trench warfare in 1915. The first hundred pages contain a general description of the French divisional organization, the instruction of infantry in field fortification, the organization of offensive and defensive sectors, the trench warfare material, the maintenance of trenches and German organization. Then follow an account of the failure of the French *attaque brusquée* on 20th December, 1914, and the settling down to siege warfare—by literal sap and mine. The greater part is devoted to the mining, which is described in detail with a good plan. The final attack on the 9th May was preceded by the successful firing of 17 mines. The charges only of the nine prepared by the 20/11 Engineer Company are given; each group of three containing a little over three tons of cheddite. The assault made apparently some time after the explosion of the mines, and four hours of bombardment, was a complete success.

J.E.E.

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NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 10.—*The Leipzig Trials.*—The *M.W.B.* has commented very little so far on the Leipzig trials, but in this number Col. Schwertfeger says that the completeness of Germany's collapse is indicated, more than anything else, by the fact that the Allies have compelled her herself to place members of the Army on their trial.

He remarks that, before the war, training in the German army was directed towards encouraging all ranks to take responsibility up to the full limit of their powers. A frequently quoted paragraph of the German Field Service Regulations says, "Everyone, from the highest to the lowest must remember that failure attributable to inaction or delay is far more blameworthy than when it is due to action, however mistaken." The writer says that no one, brought up on that principle, could ever have imagined that his action could be the subject of a civil prosecution, though he does not wish to imply that war justifies all kinds of action, or that, during hostilities, all feelings of common decency and sympathy should be put aside. He admits, however, that the severity and length of the war, combined with the necessity for taking every possible measure of self-protection did tend to push these feelings into the background; but whatever was done, was done from patriotic motives, which by Germans, as well as by other civilized nations, are placed among the highest that influence human action.

He next considers what should be the attitude of past and present officers towards those sentenced at Leipzig, and begins by disclaiming any desire to criticize the judges, who performed a most difficult and distasteful task as well as anyone possibly could, as was admitted in the English parliament. In past days the code of honour of Army and Navy officers forbade any intercourse with those sentenced to imprisonment and there was no place for them on the public service.

Should the comrades, who have been dragged by the Entente before a German court, and sentenced by a German judge, be also outcast?

Before answering this, he points out that it was impossible for the court to enter fully into the atmosphere of war, with its terrible physical and mental strain. Under this strain natures completely changed and normal thoughts were often completely absent. He claims that it is to the materialist form, which the war so soon adopted, that the guilt of such crimes as were committed must be ascribed. The usual counter-accusations against the allies follow; and though he goes further than most, and admits that sometimes Germans did do things they ought not to have done, yet, in view of the fact that the trials were insisted on, chiefly to drag Germany's name in the dust, and not to punish wrong-doing, he holds that those sentenced should not be cast out;

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rather should they be made to feel that, in their time of trouble, they have with them the sympathy and respect of all their comrades.

Col. Schwertfeger has made the best of a bad job.

Roumania's Preparation for the Great War.—Some figures, obtained from a Roumanian source, are given to show how preparations were pushed forward from the beginning of 1914. The greatest difficulty lay in finding officers; of these there were in 1914 only 4,150, increased by July, 1916, to 6,900; at the latter date the number of officer cadets was 1,606, actually under instruction, with another 1,604 in reserve. Credits were voted without stint, and the country was self-supporting in most of the material essentials.

There seems to have been an inconvenient variation in types of small arms, which included 180,000 Martini rifles of 1879 pattern. The grand total of all ranks, including all reserves, amounted, on the declaration of war, to 1,250,000 as compared with about 400,000 in 1913. The magazines were full, equipment and clothing was good and ample, and hospitals with 76,000 beds were organized and, as regards material at any rate, everything in any way possible seems to have been done.

Emigration.—Organizations have been set up in Germany to assist and advise intending emigrants. If their first advice is followed they will have little to do, for in the case of almost every country the advice to those about to emigrate is "don't." Only in South America do there appear to be any openings for Germans, and even there the capital required is within the reach of very few.

Obituary Notice.—The death of Field-Marshal Karl von Bülow is announced. He commanded the 2nd German Army in the beginning of the war and it was probably largely because of his appreciation of the situation on the 9th of September, 1914, that the retreat of the Germans took place. With his death one of the principal actors in the Hentsch drama is lost.

No. 11.—*Russia and Poland.*—The Russian Army is undergoing a reorganization which, according to the *M.W.B.* renders it temporarily unavailable; eventually however its efficiency will probably be increased. A course of instruction for regimental and divisional commanders seems to have revealed an unheard-of degree of ignorance and the course has had to be extended. These higher officers are much discontented with their pay and there is a suggestion of abolishing the equal pay system.

At present the only troublesome fronts are in South Russia and Western Siberia, though the friendly "Republic of the Far East" feels itself threatened by Semenov. The extent to which actual support has been given to Mustapha Kemal is said to be doubtful and the *M.W.B.* does not believe that anything has really been done. The economic situation is hopeless.

Poland.—Polish action in Upper Silesia is, of course, heartily condemned. It is stated that seven Divisions of the Polish Army are stationed round about the district and that the skill with which the Poles form, organize, and control irregular and secret bands among the villages, is a great danger to Germany. Little hope is felt that the Vilna question will reach any permanent settlement in the near future.

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Training is going on vigorously; it follows French lines and is directed by a French mission under General Niessel.

Prohibition of Uniform.—Demobilized officers are no longer allowed to wear their uniform, and a Major Anker finds this most unjust; not, of course, on political, but merely on economic grounds. Numberless officers have been accustomed to wearing their old uniforms on all festive occasions. When the civilian at funerals or small gatherings wears his tail-coat or "smoking," at weddings and christenings his "frock," or for visiting, for parties and such like his "cut-away" and "cylinder," the officer has worn his uniform. This was not from militarism or because he was a re-actionary, but merely because he possessed neither "frock" nor "smoking," "cut-away" nor "cylinder," and could not, in these days, pay the thousands of marks necessary to acquire them.

And so Major Anker will no longer be able to attend the funerals of his friends, nor the weddings of his relations, and, incidentally, one more difficulty has been placed in the way of that maintenance of military traditions, which is so strenuously sought for by many in Germany.

No. 12.—*Germany's Casualties in the War.*—General Altrock has collected the following figures showing the numbers wounded during the war. The information is from official sources, but does not allow for those who were wounded more than once.

Generals	1
Generals of Infantry	5
Lieut.-Generals	20
Major-Generals	61
Colonels	145
Lieut.-Colonels	267
Majors	1312
Captains	6,900
Lieutenants	5,650
Sub-Lieutenants	76,271
Ensigns	4,776
Naval Officers	799
Total	96,207
Medical officers	2,200
Veterinary officers	158

For other ranks the figures are:—

Serjeants and upwards	144,790
Rank and file	3,969,852
Others	1,283
Total	4,116,825
Colonial (White) Troops	964
Navy	30,286
	4,148,075

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The grand totals of casualties work out as follows :—

	Officers.	Medical Officers.	Vety. Officers.	N.C.O.'s and Men.	Officials.	Total.
Wounded ..	96,207	2,200	158	4,148,075	503	4,247,143
Killed	53,323	1,675	183	1,751,807	1,555	1,808,545
Total casualties ..	149,530	3,875	341	5,899,884	2,058	6,055 688

In addition the deaths among native troops are estimated at 14,000.

Ludendorff and the Armistice.—The *Berliner Tageblatt* has written an attack on G.H.Q. saying, " Why did not Ludendorff himself conduct the Armistice negotiations, after he had so strongly demanded them ? Why did not G.H.Q. send one of its leading personalities to carry through this military operation ? All these gentlemen simply wriggled out of the unwelcome task, in order to avoid the responsibilities which the collapse of their military plans had thrown on their shoulders."

General Ludendorff writes to the *M.W.B.* to point out that the facts of the case are as follows :—

In the beginning of October, 1918 a commission representing the Army and the Navy assembled at Spa to deal with Armistice questions as soon as the negotiations with President Wilson had made sufficient progress. It was expected that the Secretary of State, von Hintze, would then join the commission. It is well known that G.H.Q. proposed to offer nothing more than the evacuation of the occupied territory in three or four months, but the Chancellor and the Cabinet went further and surrendered the U-boat point before negotiations began, in spite of the protests of Ludendorff and Scheer. The former did his utmost to influence the proceedings and to insist that Wilson should be asked to state exactly what he required. He tried also to get a good foundation for the negotiations and begged the Chancellor to make a declaration to the nation, pointing out the consequences of peace at any price, so as to raise its moral courage for further resistance.

On the 25th October Ludendorff resigned before the negotiations began, and in any case would not have been acceptable to the Entente as a negotiator, for it is reliably reported that at French G.H.Q. the first paragraph of the conditions stated, " There shall be no dealing with Ludendorff or other members of G.H.Q. but only with a commission chosen by the Reichstag."

On the 6th November Erzberger was nominated as member and General von Gundell as president of the commission, but on the 7th the former claimed the leadership and von Gundell stopped at home. Erzberger left a large number of the experts behind and only took General von Winterfeldt and Captain Vanselow with him.

The *Berliner Tageblatt* is therefore quite wrong. Experts were ready and G.H.Q. was not trying to avoid any responsibility. Erzberger was not content with a secondary rôle, but pushed himself to the top and deliberately thrust aside the expert help which was offered to him.

Officers' and Men's Associations.—The *M.W.B.* continues to insert notices regarding these free of cost, and their number is certainly not diminishing. In this issue 25 meetings are announced.

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No. 13.—*Accusations against Officers.*—The *M.W.B.* says, truly enough, that it never indulges in anti-semitism, but that, when the old officers' Corps is attacked it must be defended, even if the attack comes from a Jewish source. This time a Hamburg Jewish paper writes :—

" Nothing so shameless has ever been seen as the cowardice of the regular officers. The slightest injury or indisposition was welcomed as an excuse to hurry to the rear and spend months and years in the Depôt, carrying on the distant war from its comfortable officers' mess. In particular did the regular medical officer delight in sending the Jewish doctors to the front line, while they themselves remained in divisional headquarters."

It has been decided that no statements defamatory to the old corps of officers can be made the subject of libel action, and so many are seizing the chance of working off their spite, but it seems curious that the *M.W.B.* should, by repeating them, give such absurd statements the publicity which they desire more than they deserve.

Hindenburg and the Armistice.—Since Erzberger's murder it has been stated that he was warmly thanked by Hindenburg for his services in the Armistice negotiations.

Hindenburg now writes to say that he did not thank him warmly, and that the ordinary forms of politeness have been given an importance that does not belong to them.

Regimental Re-unions.—In consequence of the murder of Erzberger many applications have been made, by the organizations of the left, to the authorities, asking that regimental re-unions may be prohibited. In most cases the governments have given way and have forbidden the meetings, at any rate while feelings are so excited, but the *M.W.B.* is glad to see that the Würtemberg government declines to do so and says that freedom of meeting must be given to both sides alike.

Coloured Troops in the French Army of Occupation.—It is noted that a number of young Moorish officers from the Officers' School at Mekinez will soon be joining the Army of Occupation. The hope is expressed that they will succeed in tightening up the discipline of their men which has, it is said, been recently deteriorating. (There is other evidence, from a neutral source, showing that the discipline of the coloured troops is very good, but " the black shame " is a thing the Germans cannot get over.) These young officers are apparently to have the same responsibilities and rights as any other French officers and will draw the same pay.

L. CHENEVIX-TRENCH, *Major, R.E.*

REVUE MILITAIRE GÉNÉRALE.

April, 1921.

Events in Upper Silesia.—This letter embraces the period Dec., 1920 to Feb., 1921, and tells of the increasing impatience of the Poles due to the continuance of German administration. This has led to incidents such as the blowing up of statues of the Kaiser etc., but lurid accounts of

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terrorism published in the German press rather tended to dissuade German residents from returning for the plebiscite, and had to be acknowledged as exaggerations.. Unfortunately for the latter purpose the Berlin correspondent of the *Manchester Guardian* stated that " the Polish terror is not an invention of German propaganda," adding that he had lately been travelling in the country. If he did so he was luckier than Mrs. Buxton, who, on reaching Oppeln was politely provided with a seat in the next train for Breslau, and several other possibly undesirable visitors were deported. Small stores of firearms were found in Polish houses, but large stocks have been discovered in German workshops, and entire wagon loads of German rifles and machine guns, issued from Neisse, and some dated 1920, were seized on the railway. The *Ostdeutsche Morgenpost* of 31st Dec., announced a Polish insurrection for January. On 14th January, M. Korfanty warned the Poles to beware of *agents provocateurs*. Each nation accused the other of making military preparations, and the Poles were alarmed at the creation of the " Central Co. of Auto-transport " whose huge lorries seemed designed to support armour.

The plebiscite regulations did not altogether satisfy either party. It was a great relief when the Pope decided that oaths of allegiance to Germany or the Emperor would not be considered binding on voters. There was great excitement in German circles when the press announced that a great landed proprietor, Count Oppersdorf, had attended a Polish political meeting, at which other German officials were also present, which passed a resolution in favour of handing over the left bank of the Oder to Poland. The *Deutsche Volkspartei* censured the count, and matters were not improved when it was remembered that his wife was a Princess Radziwill. The Kasino Gesellschaft removed the count's name from its list of members. The interest of this and similar cases lies in the fact that certain influential Germans evidently have no blind faith in Upper Silesia remaining within the Empire, and that the German public realizes this and resents it. Many municipal elections have gone in favour of the Poles and even Polish mayors have been elected, a thing unheard of previously.

Germans maintain that the output of coal must diminish when their directors and managers leave, to which the Poles reply that enough will stay to tide over the period until successors will have been trained in their own schools. Polish workmen declare that the output will diminish if the mines are given to Germany. It is stated that Upper Silesia supplies only 10 per cent. of the German consumption of coal and coke. Poland has no intention of not supplying what is prescribed for Germany in the Versailles Treaty, all that she asks is that she may supply her other neighbours. It would be easy to connect up the metre gauge railway to a large station at Myslowitz, whence canalization of the Brynica for 25 miles would connect with the Vistula.

The Poles are trying to induce many German functionaries to remain, and will welcome them as long as they do not pursue an anti-Polish policy. Germans point out the advantages of joining an economically sound Germany, instead of an impoverished Poland with a future of warfare opening before her (but who supported the Bol-

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shevists last summer ?) and as regards peace attending Germany, those are curious pacifists who have such a fancy for rifles that they will not surrender them and enrol themselves in various Orgeshs. Whatever the result of the plebiscite may be one cannot but admire the way in which the Poles of Upper Silesia have regained their national consciousness in the last 20 years, have recognized in M. Korfanty their most influential representative, and have disciplined themselves to follow the advice of that remarkable organizer.

July, 1921.

The Revision of the Regulations and our War Doctrines.—The study by Lucius, extracts from which have already appeared in the *R.E. Journal* for July and September, 1921, is continued in this number. Dealing with what he calls the second phase of the third period, Lucius discusses the offensives in Artois (9th May and 18th June, 1915), and Champagne-Artois (on 25th Sept, 1915). The first, an attack by five Army Corps on a front of 15 km., was only of real effect in the centre, where the infantry in less than an hour was able to reach the Vimy Ridge, 4 km. from where they had started. On the right the first line trenches only were captured with difficulty, having been insufficiently bombarded, and the reserves were unable to take full advantage of the success gained in the centre, since the breach was so narrow that the enemy was able to close it again ; and the later attack on 18th June was only a partial success and dearly won. The lessons learnt by the *attack* were :—that a single position can be pierced if the requisite number of heavy guns is available to demolish the works of defence on a sufficiently wide front ; Infantry reserves were still too far back, and the troops who penetrated the furthest into the enemy's position were not reinforced in time. This was dealt with in an Amendment dated 26th May, which also insisted on the value of surprise, which might be secured during the general bombardment preceding the attack by bursts of fire separated by silences, the end of each being marked by a lengthening of the range so as to suggest the imminence of the attack, and so might induce the enemy to man his trenches prematurely. Every possible step must be taken beforehand to complete the success of a break-through, and a Supplement to the Instructions, issued on 18th June, suggested that here was a great opportunity for cavalry. The enemy's artillery must be captured in the first rush in order thoroughly to dislocate his powers of resistance. It was becoming evident that the artillery of the defence must be destroyed or neutralized, and counter-battery work was to be one of the most important duties of the artillery. The lessons in *defence* learnt by the French were that the existing order that not an inch of ground must be lost led to needless loss of life by holding front trenches too strongly, and so greatly weakening the supports that they could not check a successful attack until it had penetrated some distance. A Note of 8th July pointed out that as a line could always be pierced, given the necessary expenditure of heavy ammunition, it was wiser to reduce the strength of the first line and hold more troops in hand for manœuvre. Continuous trenches should be replaced by centres of resistance, separated by intervals defended by fire

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alone. This organization was applied in particular to the defence of Verdun. The construction of second positions was begun along almost the whole of the front.

From the German point of view, the danger they had run during the offensive in Artois showed the necessity for second positions. It was laid down that at least two positions were necessary, separated by such distances that the capture of the second would require an entirely new attack, and consequently a change of position of the attackers' artillery. The first position must be held strongly so as thoroughly to exhaust the attack, but this was not to imply that supports and reserves were to be drawn upon to hold the first trench, which was to be held by the necessary minimum, and counter-attacks relied upon to recover lost ground.

The plan of attack on 25th September embraced two simultaneous attacks, in Champagne and Artois (French 10th and British 1st Armies), success in which should produce important stragetic results—as on 1st September the Allied force exceeded that of the enemy by some 30 divisions, while the German reserves amounted to six divisions only, but on 25th September these were reinforced by two corps from Russia. The front in Champagne measured 35 km. with 900 heavy and more than 1,000 field guns. The Artois front was only 9 km. with 250 heavy guns. The preparations gave the enemy ample warning, and in Champagne he withdrew a large proportion of big guns to the north bank of the Dormoise, where he had prepared a second position on a reverse slope, five to six km. in rear of the first. Here the infantry attack progressed rapidly near Souain, to right and left the breach was widened to 20 km., and the enemy's batteries between the first and second positions were captured, but after an advance of three to four km. the attack was broken against the second position, the defences of which were intact. A fresh attack on 6th October, against an enemy who had had time to recover, met with little success. In Artois the French attack was only successful near Souchez and soon came to a halt; the British took Loos and Hulluch, forcing a breach six km. wide by three in depth, when they were checked by the German second position. In neither case was the enemy's front broken.

The chief lesson learnt by the *attack* was that the final check resulted from the powerlessness of an attack, split up by the first assault, to gain possession of a second position, either because its reserves were not at the required spot or because they were unable to intervene at the critical moment. The G.O.C.-in-C. blamed (1) the fresh troops for coalescing with the attacking line and causing a disorder which rendered them incapable of exerting an effort against the second position; (2) the artillery for want of method in observation and communication and so failing to destroy the accessory and flanking defences of the second position; and (3) the higher commanders for failing to set in operation in due time the means for efficient preparation for the attack on the second position. The advance of the artillery during an attack is of the utmost importance, and will occupy some time, but the attack must be rapid to ensure the maximum of surprise and demoralization. Yet no consideration can over-ride the fact that obstacles must be destroyed before they can be surmounted.

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From the French point of view the lessons in *defence* were shown in the orders for the period which must now elapse before the expected spring offensive. Second positions were to be concealed in woods and along reverse slopes, and behind them were to be fortified areas, to guide a hostile attack along defined routes, and to serve as supporting points for the counter-offensive. In order to save time later and realize surprise as far as possible, all works which would require time to prepare and the execution of which could not be concealed, such as communication trenches, places of arms, emplacements for batteries and trench mortars, etc., were to be put in hand all along the front, to create uncertainty as to the point to be actually chosen for attack. A Note, dated 5th December, 1915, pointed out that the power inherent in the attack did not permit of absolute reliance on the resistance of fortifications. The first line, generally continuous, held lightly and covered with well-concealed obstacles, was the *combat position* of the outposts to hold the enemy during the preparation of the counter-offensive, in maximum strength, in the *offensive battlefield*, which had been prepared in rear of it. The artillery was to reply to the enemy preparation fire and at the moment of assault to concentrate on the enemy's infantry.

The conclusions drawn by the Germans from the defensive point of view, and revealed by captured documents, were that they considered that the second position was capable of stopping a break-through so long as the first line held long enough to allow of the occupation of the lines in rear by the reserves. Holding the first line to the death and absorbing the supports and reserves into it should be strictly avoided if continuous opposition was to be offered to the enemy. Owing to the demoralizing effect of more than three days' bombardment, several units had been surprised in their shelters. The effect of gas did not come up to expectation. Commanders experienced the greatest difficulty during the battle in keeping themselves informed of the situation, and means of communication must be increased. The German artillery action was essentially defensive—barrage fire, as opposed to destructive and counter-battery fire—in this respect they were less advanced than the French. On the other hand, as a rule, the artillery gave the greatest support to the infantry, only failing when ammunition ran short, which emphasized the importance of accumulating large stocks near the guns during the artillery preparation. The Germans also recognized the difficulty of obtaining surprise in the attack on a large scale.

The conclusions drawn from the events of 1915 were, therefore, as regards the offensive, two opposing ones, one referred to in the Note of 2nd January, pointing to the limited effect of the French artillery and advocating successive attacks, the other expressed in the Instructions of 16th April and based on the rapid attack carried through to open ground. The attack of 9th May showed that if the artillery was imperfect it was at least capable of breaching a fortified position of limited depth. By the 25th September the second position came into being, and the principles of 2nd January, *i.e.*, the slower development of the operations, or successive attacks, were re-established. The impossibility of surprise is note-worthy. But there may be, besides *strategic surprise*,

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which leaves the enemy uncertain of the region to be attacked, and prevents him from concentrating reserves at that point, *tactical surprise*, which leaves him uncertain of the moment of attack and the particular front selected in a region already known. The Notes and Instructions implicitly admit of the impossibility of securing the first in a war of position, but the latter is possible at any rate as regards the actual moment of attack.

Preparation for launching an offensive carried out long previously along the whole front, as proposed in May, 1915, might lead to the possibility of effecting a stragetic surprise ; a real tactical surprise could only be attained by the possession of heavy quick-firing guns sufficient to reduce the artillery preparation to a matter of a few hours. Owing to the number of their heavy quick-firers and ruthlessness in the employment of asphyxiating gas, the Germans were in a better position than the Allies to effect surprises of both natures, and constantly strove to do so.

But stragetic surprise could also be obtained by *manœuvre*. Experience had shown that to oppose attacks the enemy immediately diverted behind the menaced front the supports from the neighbouring unthreatened sectors, until he had time to concentrate his reserves. Profit might be taken of the weakening of other sectors to attack one of the points of least resistance. Two or three successive positions might be carried if the enemy had not at his disposition troops to defend them. To realize such a conception numerous points of the line must be prepared in advance as jumping-off points, and infantry, artillery and ammunition be available to feed simultaneously the several offensives That the High Command saw the possibility of this has been shown above ; that it was not carried into effect is doubtless due to lack of effectives and material.

The 1915 offensive entailed heavy loss of life, and unfortunately it was not recognized that this was due to too dense formations, however the partial successes achieved raised the *morale* of the troops. At the same time they drew attention to the probable length of the war and led to organization to that end, and for a war of position. Aviation advanced in efficiency and in the scope of its activities, especially *liaison* with infantry and artillery, the heavy artillery increased in numbers and skill. The influence of General Pétain began to make itself felt.

A. R. REYNOLDS.

(To be continued.)

REVUE MILITAIRE SUISSE.

No. 5.—*May*, 1921.

The Evolution of Methods of the Offensive.—The article by Lieut.-Colonel H. Corda on the above subject begun in the April number for the *Revue* is concluded in the number under notice ; he deals in this part of his paper with the methods adopted to take the enemy by surprise. Surprise, he points out, may be both strategical—as in cases in which an attack is delivered in a region in which insufficient reserves are held by an enemy—as well as tactical—as in cases in which an attack is made

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unexpectedly on a particular front with great suddenness. In a general way surprise is effected :—(1) by taking the initiative ; (2) by observing secrecy in relation to projected attacks ; (3) by rapidity in carrying out an attack. However, to obtain the effect of surprise attention has to be paid to a vast number of details ; these were dealt with in Instructions, dated October 30th, 1917, issued to the French Army. The main points requiring attention are touched upon by Colonel Corda in his paper under seven headings dealing with the following matters :—(i) observance of strict secrecy, and the avoidance of any measures likely to attract the attention of the enemy's espionage service ; (ii.) no new works to be carried out, preliminary to the surprise attack, on the selected front ; (iii.) the deception of the enemy with regard to preparations in progress ; *e.g.*, by strict control of all movements on the front—which should be carried out at night only—and by a judicious use of camouflage ; (iv.) care to be taken not to disclose prematurely the extent of the aeronautical services (*e.g.*, captive balloons should not be sent up as a preparatory measure) on the selected front ; (v.) " formations " intended for the attack should not be moved forward until the preparations are completed ; (vi.) need for the " artillery preparation " being reduced ; and (vii.) necessity for rapidity in the delivery of two successive attacks.

The events of 1918 are examined and discussed by Colonel Corda, who deals at some length with the subject of the " artillery preparation " under three main heads :—(*a*) the placing of the artillery in position, including the execution of the necessary works in connection with the entrenching, etc., of the guns, the rate at which additional artillery can be conveniently " absorbed " in the selected front and the ammunition supply ; (*b*) the duration of the " artillery preparation," including the " density in artillery " on the selected front, the use of poison-gas shells, and the employment of tanks ; and (*c*) the advance of the artillery from its first positions.

Colonel Corda in conclusion expresses the opinion that in future wars it is not likely that battles will take place on " stabilized fronts " as was the case during the three years of trench warfare in the Western Theatre ; continuous progress in the field of industry is likely greatly to modify the methods of war. However, whilst the evolution of the art will assuredly continue, it will do so without affecting the fundamental principles either of strategy or tactics, which will remain unchanged.

Colonel Corda refers further to the fact that during the Great War, whilst the artillery and engineers in the French Army were practically doubled, the numbers of the cavalry and infantry were reduced ; in view of modern developments, the importance of the technical troops will continue to increase as time progresses, and armies will require a large proportion of men of high intellectual capacity, men who, moreover, are imbued with a scientific spirit.

W. A. J. O'MEARA.

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THE ORDNANCE SURVEY OF THE UNITED KINGDOM.

A lecture delivered at the S.M.E., Chatham, on 13th October, 1921, by Colonel Sir CHARLES CLOSE, K.B.E., C.B., F.R.S., Director-General O.S.

ACCORDING to the Oxford Dictionary the word *Ordnance* is a "syncopated variant" of Ordinance, which is itself derived from the old French "Ordenance," a regulation and an arraying in order. In the 17th century the word *Ordnance* came to be exclusively applied to artillery and engineer personnel and material, and the services relating to these.

"Headquarters of Engineers existed in the Tower of London before 1350, and a century later developed into the Office of Ordnance (afterwards the Board of Ordnance), whose duty it was to administer all matters connected with fortification, artillery and ordnance stores" (1). It is perhaps doubtful if the Office of Ordnance was formally founded in the 15th century, but it is probable that it developed during that century into something like the form which it substantially retained for centuries, in fact, until its abolition in 1854. In one form or another it had had a continuous history of some 500 years. The Master General and Board of Ordnance were a genuine power in the land, and the position and status of the Master General in those days differed considerably from those of the Officer who now bears the same title. The Master General was in some periods the King's principal military adviser. It was a post held by the great Duke of Wellington, and it was during his tenure of the Office that the first three Survey Companies were formed (in 1824-25).

The Tower of London remained the headquarters of the Ordnance Survey from its foundation, which may be dated 1791, to 1841. In the latter year the offices of the Survey in the Tower were destroyed by fire, and it is to this mere accident that the Department owes the transfer of its headquarters to Southampton, where there were some barracks, under the control of the Board of Ordnance, available at the time.

But before proceeding further with an outline of the history of the Survey it may be as well to glance at the previous development of cartography in this country.

There is in the Bodleian Library at Oxford an early map of Great Britain, dated about A.D. 1300. This map portrays the features of England, on the whole, well; the chief towns, rivers, castles and abbeys are given, and distances are marked along the roads, which

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are shown by red lines. This map is a genuine piece of map-making and is not based on tradition. In these respects it differs from contemporary maps, such as the *Mappa Mundi* of Hereford, which was produced about the same date. It is, perhaps, not stretching the imagination too much to assume that the Bodleian map was used by *Dominus Rex* in his journeys about the country, or by officials in his court.

This is not a treatise on old maps, so I will skip three centuries and mention the maps produced in the reign of Elizabeth, of which there are several. As an example, take this sheet of Kent dated 1596. It is engraved on copper, it is clear and easily legible; the hills are shown in profile, as in the most ancient known maps—those of Egypt. But it is woefully inexact. Between Rochester Bridge and the North Foreland there is an error of many miles. It was no doubt constructed by compass and cyclometer or some such distance measurer, and is in fact a compilation of compass sketches.

Let us move on a century and a half and we come to our first elaborate official survey, *i.e.*, the Down Survey, so called because it was plotted "down" on paper; at least that I believe is the usual explanation of the name, though it seems rather a weak one. This Survey was ordered by the Commonwealth in 1656. Its object was to lay down the boundaries of baronies, townlands, parishes, forfeited lands, etc., "after the late horrid rebellion." The contract price was 1d. an acre, or £2 13s. 4d. a square mile, and the work was carried out under the direction of Dr. William Petty, ancestor of Lord Lansdowne. Hills were shown in profile. The method of surveying was, I suppose, with chain and offset rod. Of course surveying was very fairly developed during the 16th and 17th centuries and there are many contemporary treatises on the subject.

We now come to what some consider the real germ and origin of the Ordnance Survey. In August 1745, Prince Charles, the young Pretender, grandson of James II., landed at Borradale on the West Highland coast and collected a small force of 2,000 men, MacDonalds, Camerons and others, and marched south. He entered Edinburgh unopposed on the 16th September and routed Cope at Prestonpans on the 26th. He then marched as far into England as Derby, but was obliged to retreat, and was defeated by Cumberland at Culloden on the 16th April 1746.

"The credit of originating and carrying into execution the first tangible project for a systematic topographical survey of part of the kingdom is to be divided between two Engineer Officers, both at the time holding distinguished positions on the Staff of the British Army" (2). The operations in the Highlands of 1746, and the subsequent pacification, brought forcibly to attention the need for a map of that region. Lieut.-General Watson, Deputy-Quarter-Master General to the Duke of Cumberland, commenced the mapping

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of the district round Fort Augustus with the aid of troops quartered there; William Roy, Assistant-Quarter-Master-General, assisted his Chief in the work. "It was General Watson," Roy says, "who first conceived the idea of making a map of the Highlands—which being undertaken under the auspices of the Duke of Cumberland, and meant at first to be confined to the Highlands only, was nevertheless at last extended to the Lowlands." The work was, in Roy's words, "rather to be considered as a magnificent military sketch than a very accurate map," and was interrupted by the breaking out, in 1755, of war with France and the work was never completed. But from 1747 onwards the idea of a military map, not of Scotland only, but of the whole kingdom, was never lost sight of by a small group of officers.

This original map by Watson and Roy is in the British Museum. The scale is the large one of 1,000 yards to one inch. I think that it deserves more study than has been given to it. It was no doubt executed by pacing and with compass. The hills are now no longer in profile but are represented by rough stump shading. And so ends the first chapter in the history of the endeavour to make a military map of Great Britain.

The next chapter in the history serves to show how two distinct motives contributed to the eventual establishment of the Survey. We have seen how military necessities originated the idea, but the next impulse came, not from war, but from science. "In October, 1783 the French Ambassador transmitted to Mr. Fox a memoir," by Cassini the astronomer, in which he advocated the carrying out a triangulation from London across the Straits of Dover to be connected with the existing French triangulation, the immediate purpose being to join the observatories of Paris and Greenwich and to ascertain their relative situations.

Roy, now a General, was put in charge of the work. It is an old story how a base was measured on Hounslow Heath, men from the 12th Regiment of Foot helping. The measurement was made by three different means, by steel chains, by glass rods and by wooden rods; and the King, the Master General of the Ordnance, and the President of the Royal Society visited the work whilst it was in progress. The terminal sites are still preserved and I gave an order only the other day for painting the railings round one of them. The interest in this base is, however, only historical and sentimental. The maps of the United Kingdom do not now depend upon it.

The triangulation extended from this and other bases was of a high degree of accuracy for the times, thanks to Ramsden the instrument maker, who built two 3-foot theodolites for the work, one for the Royal Society in 1784, and one for the Board of Ordnance in 1791. One of these is at Southampton and one at the Science Museum at South Kensington. The 3-foot theodolite at Southampton was lent a few weeks ago, for exhibition in a shop window of Messrs.

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Selfridge in Oxford Street. I do not think that Roy and Ramsden would have objected to its thus being made use of, for Ordnance Survey purposes, 137 years after it was made. They would rather have rejoiced at its revived usefulness.

In the triangulation of the flatter parts of England a free use was made of church towers and spires; in the hillier regions this was, of course, unnecessary. The principal triangulation took the form of a net work covering the surface of the United Kingdom with triangles, of which the average length of the sides was thirty-five and a half miles. This work was completed in the field in 1852 and the reductions were carried out by the most distinguished geodesist who has ever served on the Survey, the late Colonel A. R. Clarke, F.R.S., R.E. The bases on which the triangulation depends are the Lough Foyle Base, measured in 1827, and the Salisbury Plain Base, remeasured in 1848.

We must now, for a moment, look back to the earlier days of the Survey to see how the practical work of map-making fared. And first it is to be noted that the formal establishment of the Ordnance Survey occurred on the 12th July 1791, by order of the Master General and Board of Ordnance, "an extra allowance" of 22/6 a day being paid to Major Williams and 7/6 to Lieut. Mudge "besides the usual allowance per mile for travelling from place to place." Both these Officers belonged to the Royal Artillery and "the party of Artillery who were to assist were to receive one shilling per day each while employed."

The first sheet of the 1-in. map was published in 1801, and, until 1824, the Survey had two objects only, the execution of the great triangulation and the production of the 1-in. map. These were the days of small things so far as establishment was concerned. In 1823 the establishment consisted of 7 Officers, 7 Surveyors, 8 Draughtsmen, 6 Engravers; a total of 28 all told.

But in 1824-25 the Duke of Wellington ordered the formation of 3 Survey Companies, the 13th 14th and 16th Companies R.E., and this was in consequence of the Government authorization of the execution of a 6-in. map of Ireland.

It may be asked,—if the great triangulation was not finished until 1852, how was it that the old 1-in. sheets were issued in earlier days? I have always assumed that the answer to this question is, that where the triangulation existed the 1-in. map was based on it, and where it did not exist, the work was carried out by compass alone. The early engraved sheets are beautiful productions and give an interesting picture of England a hundred years ago.

Contours were adopted by Colby for the 6-in. sheets of Ireland in 1839, but they did not appear on the 1-in. (which till then was only hachured), until 1892. The history of the invention of contouring appears to be the following. About the middle of the

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18th century sea-bed contours were drawn on certain charts published by the French Government, but the first example of land contours, in this country at any rate, is due to a purely scientific investigation carried out by Dr. Charles Hutton, F.R.S., of the Royal Military Academy, Woolwich. Hutton was calculating the density of the earth by means of a determination of the attraction of the mountain Schiehallion in Perthshire, and he says that he "fell upon" the method of "connecting together by a faint line all the points (on the hill) which were of the same relative altitude." This was in 1778.

Here we have an excellent example of the favourable reaction of pure science upon practical affairs.

The mean date of the Great Triangulation is about 1820, and, as might be expected, its angular accuracy is not up to modern standards. This led several people, including myself, to suggest a remeasurement of those portions which form parts of the great European Arcs. But it occurred to me in 1908 that, instead of assuming the fact that a general remeasurement was desirable, it might be well to test a small portion of the old work remote from either of the two bases. Accordingly, on the advice of the British Association, a new base was measured at Lossiemouth by Major W. J. Johnston, R.E., in 1909, and a small net-work was extended from it.

Captain H. L. Winterbotham reduced this test triangulation and has written an excellent report on the subject. Broadly the investigation shows that the linear errors of the old net-work are in much the same terms as those to be expected in modern triangulation carried out in chains over similar areas. The error of any side is of the order of one inch to one mile. Or the matter might be put thus, if the 700 miles of meridional arc between the Straits of Dover and Saxavord, in the Shetland Isles, were measured with every modern refinement, it is not likely that the new measurement would differ from the old by much more than 25 yards. The influence on modern figures of the earth of any such remeasurement would be insignificant.

And here, perhaps, it is a good place to say that the pursuit of mean Figures of the Earth is, for the present at any rate, given up by modern geodesists. The mean figure is well enough known, what we must now examine are local figures, attractions and deviations.

I must pass by, for want of time, the history of what is sometimes called the battle of the scales, which lasted from 1851 to 1858. In the result the Ordnance Survey standard scales became what they are now, namely, *the large scales* 1/2500, or about 25 in. to one mile, and the scale of 6 in. to one mile; and the *small scales* one inch, half-inch and quarter-inch to one mile, and the one-tenth-inch and the one to one million. The whole of the United Kingdom has been surveyed on the large scale of 1/2500, (excluding mountainous and waste areas), and there are about 80,000 plates of the map on this

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scale; the whole of the United Kingdom has been mapped on the scale of 6 in. to one mile and on the small scales. The latest part of the United Kingdom to be surveyed on the largest scale was Ireland. The 1/2500 survey of that country was begun in 1887 and was finished in 1914, having occupied 27 years. The expenditure was about £1,400,000, giving an average cost of £47 per square mile, or about 1/6 per acre. Now, there is a rule which is sometimes useful to surveyors, that in similar conditions, the cost varies approximately as the scale, so that to make a 1-inch map of Ireland, *de novo*, would have cost, at pre-war prices, about £1 17s. 0d a square mile. This may be compared with the actual pre-war cost, per square mile, of the Orange Free State half-inch survey, which was 8s. And from this we may judge that Ireland is at least twice as complicated a country as the Orange Free State.

The methods of survey adopted by our predecessors, and carried on until 1914, were well considered and could hardly be improved. A triangulation, primary, secondary, tertiary, the latter with sides averaging a little more than a mile long; a rigorous chain survey; then the plotting and examination in the field. And with regard to this examination the device was adopted of making intentional errors on the tracing sent to the field examiner. If the field examiner did not detect these errors he got into trouble.

There is a technicality, which affects the use of the large-scale maps, which I must mention briefly, namely, the fact that, owing to the curvature of the earth, it is not possible to plot the large-scale sheets on one projection for the whole country. Our predecessors were, however, a little timid in the matter and undoubtedly used too many independent meridians. Before the war we were engaged in reducing the numbers of these and we had already absorbed several when the war broke out. In these days of financial stringency, the reduction of the number of independent meridians is, for the time, suspended. But the expense is not very formidable, in spite of the report of a Committee that the work would cost hundreds of thousands of pounds. Committees and commissions are not infallible and I advise every one to read their reports with a free mind and not to be hypnotized by them. Anyway we successfully disregarded the opinion of the Committee in question.

Those old Officers of the Corps and of the sister Regiment were much to be envied who took part in the first Survey of the United Kingdom. They got to know with affection and exact knowledge the surface of this country. What experiences they had on the mountain tops of the Highlands and of Cumberland, Wales and Ireland! What journeys they took over the unspoilt countryside! What kindly help they received from all classes of their fellow countrymen! And how happily they carried out their labours and how successfully, until the Ordnance Survey became, without rival,

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the finest Survey in the world! There is a poem by Wordsworth, not perhaps very well known, written with a slate pencil on a stone, on the side of the mountain of Black Comb in Cumberland, and this poem gives a century-old glimpse into the everyday life of one of these old Officers of the Survey (3) :—

"Stay, bold Adventurer; rest awhile thy limbs
On this commodious seat! for much remains
Of hard ascent before thou reach the top
Of this huge Eminence,—from blackness named,
And, to far travelled storms of sea and land,
A favourite spot of tournament and war!
. . . . . .
Know, if thou grudge not to prolong thy rest,
That on the summit whither thou art bound,
A geographic labourer pitched his tent,
With books supplied and instruments of art,
To measure height and distance; lonely task,
Week after week pursued! —To him was given
Full many a glimpse, (but sparingly bestowed
On timid man), of Nature's processes
Upon the exalted hills. He made report
That once while there he plied his studious work
Within that canvas dwelling, colours, lines,
And the whole surface of the outspread map,
Became invisible: for all around
Had darkness fallen—unthreatened, unproclaimed—
As if the golden day itself had been
Extinguished in a moment; total gloom,
In which he sate alone, with unclosed eyes,
Upon the blinded mountain's silent top!"

It is now time to turn to the existing constitution and work of the Survey. From the early days of the Survey civilian employees were added to the strength of the Department to assist in the prosecution of the work. These were known as first-class assistants, second-class assistants, and "men dragging the chain." The final adoption of the 25 in. scale for Great Britain in 1858, the speeding up of the maps on this scale in the 'eighties of the last century, and the commencement of the Irish 25-in. map in 1887, all resulted in the absorption of large numbers of civilian assistants and labourers. The civilian assistants can now, given good health and efficiency, all become pensionable, a very reasonable and proper regulation. Moreover, the Royal Engineer rank and file of the three Survey Companies, can, after serving 21 years in the Army, join the ranks of the pensionable civil assistants, and can continue to serve as civilians until they reach the age of 60.

The Ordnance Survey is thus, at the present time, a composite body, made up of officers, serving Royal Engineers of the Survey

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Companies, ex-Royal Engineers who have become pensionable civil assistants, civil assistants, labourers, women, and boys under training. The total strength of the Survey in April 1914 was 2,077, but, owing to the necessity for economy, this strength has been brought down, and the Survey total is now (October 1921) 1,425, the programme of work being correspondingly reduced.

The authorized normal programme of work is, now, the following:—

(1) The revision, on the 25-in. scale, every 20 years, of those counties with an average population of 100 per square mile or over.
(2) The revision, on the same scale, of the other counties every 40 years.
(3) The publication of the revised 6-in. maps based on the 25-in.
(4) The revision of the small-scale maps every 15 years.

(It is probable that the surveys of Northern and Southern Ireland will be handed over to the Governments of those countries.)

To this programme should be added:—the training of military surveyors for service with the Army in the field, and the training of topographers for military surveys in peace time, and for boundary commissions; and the execution of such cartographic work as may be required by the War Office, Admiralty or other Government Departments.

Without doubt, the most important functions that the Survey fulfils, are those relating to the Army; and this fact can, perhaps, best be illustrated by a brief description of what was done in the Great War.

Before the war the Survey prepared for the War Office plates of the maps of the French Staff map on the scale of 1/80,000. These maps were printed and issued to the Expeditionary Force. The French 1/80,000 was not a first-class map, even for its scale, but it was nearly all there was available in France. The Belgian maps were on larger scales and were more accurate.

When the order to mobilize was received, in August 1914, I at once communicated with the War Office and enquired if any Survey Sections would be required for the Expeditionary Force. Now, our General Staff, in common with the other General Staffs, misconceived the probable character of the war, and I was informed that no military surveyors would be wanted. Then began the process of drafting many of the men of the Survey Companies to other units of the Corps. These men were, for the most part, retrieved and posted, later on, to the Field Survey units—but this is anticipating. It is, of course, easy to be wise after the event; but trouble would have been saved if the possibility of the use of Survey units had been allowed for.

Early in November 1914, Captain H. L. Winterbotham, R.E., and

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four non-commissioned officers were sent out to France to act as a Ranging Section; the idea being to determine the position of an aeroplane when this was vertically over a hostile target. The idea did not prove a success, but the Ranging Section did. For, in a very short time the Section was employed at its legitimate and necessary work. "The struggle on the Western Front early assumed the character of a siege. Intricate and extensive systems of entrenchment, strong and concealed battery positions, trench mortars and machine-guns, resulted in a corresponding growth of accurate and scientific gunnery. For this purpose, an accurate large-scale map was essential, and, as such a map of France did not exist, a new one had to be made. . . . In January 1915 this Survey was begun. The full magnitude of the task before the surveyor was naturally not fully appreciated at this time." (4).

To trace the history of the development of the Survey Sections on the Western Front from Sections to Companies, from Companies to Battalions, and the work they did, would require a lecture itself. All that can be said now is that, under the direction of Colonel E. M. Jack, R.E. (who had formerly served on the Ordnance Survey), and with the assistance of Lieut.-Colonel Winterbotham, R.E., Lieut.-Colonel McLeod, Lieut.-Colonel Reid, Lieut.-Colonel Legh, and other officers, the work expanded until it included surveying, battery fixing, sound-ranging and flash-spotting, so that when the Armistice was declared there were no fewer than 250 officers and over 4,000 other ranks serving in the Survey Battalions. The nucleus of the whole organization was provided by the personnel trained on the Ordnance Survey, but "much credit is also due to the temporary officers who joined the Survey Battalions and who were, perhaps, the pick of the rising young surveyors, scientists and engineers of the Empire." (4).

All this time the Ordnance Survey at home was devoting itself chiefly to war duties. The establishment at Southampton early became the principal source of supply for the maps required by the Armies on the Western Front. Under the directions of the War Office and G.H.Q. the maps drawn in France were sent by specially speedy routes to be reproduced at the Ordnance Survey Office. A good deal of work was also undertaken for the Admiralty. From the 4th August 1914 to the 31st March 1919, 32,872,000 maps, plans and diagrams, were supplied, mainly for the Western Front.

The half military, half civil, organization of the Survey responded without difficulty to the demands made upon it. Altogether out of a total male personnel of about 1900 between the ages of 18 and 60, on the strength of the Department, 961 either joined up or were already in the Army. In addition to these about 800 men were specially enlisted and drafted abroad.

As work developed the average dispatch from the Ordnance Survey Office, Southampton, to France, rose to 20,000 maps a day.

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The maps were drawn and sent to us by the Field Survey Battalions, and the work of heliozincographing, printing, &c., was carried out at the Ordnance Survey Office and thousands of copies of the completed maps dispatched to G.H.Q. within two days of the arrival of the maps from France. But it eventually became necessary to establish an Overseas Branch of the Ordnance Survey, as it was found that altogether some six days were occupied from the time of the completion of the field work on the maps to the final delivery to G.H.Q. of the sheets required.

The Overseas Branch of the Ordnance Survey (O.B.O.S.) was located in the first instance, (March 1918), in a factory taken over at Wardrecques, near St. Omer, and fulfilled a very useful function. It was found, however, that this site was too close to the enemy and there was danger of the whole establishment being destroyed. It was therefore transferred to Wimereux, near Boulogne. On the 21st August the Wimereux establishment commenced work. The greatest total strength of O.B.O.S. was 181, including a detachment of 60 women of the Q.M.A.A.C. mostly recruited at Southampton. The whole was under the very efficient command of Lieut.-Colonel W. J. Johnston.

O.B.O.S. did admirable work, especially after the 21st March, 1918, when the German offensive on the Somme began. Two Field Survey Battalions were temporarily out of action and this led to very heavy demands being made on O.B.O.S., for the supply of maps to the two Armies affected. Again, on the 8th August 1918, the final British offensive began, and this entailed continuous work night and day for eleven days. O.B.O.S. fully justified its existence.

I must now pass briefly in review two other aspects of the work of the Survey, namely the scientific and artistic aspects; the scientific side of the work dividing itself into two parts, the physical and mathematical and the archæological. The chief modern undertaking on the physical and mathematical side is the execution of a revised primary level network. The field work of this new levelling of England and Wales was begun in 1912 and was finished in 1921. It has been carried out with every refinement of care. It will serve to give an idea of the accuracy of the work if it is stated that the probable error of the height of a point at Dunbar, as derived from Newlyn, some 650 miles distant, is 2 in. In connection with this levelling, three mean sea-level stations have been established, at Dunbar, Newlyn and Felixstowe, where automatic tide gauges are continuously at work. The results of this levelling will shortly be published; meanwhile it may be noted that a new form of fundamental bench mark has been devised and bench marks of this type are placed at intervals of about 30 miles all over the country. They are surrounded by railings and look rather like graves with small granite headstones.

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The officers chiefly connected with this primary levelling are Major E. O. Henrici, Lieut.-Colonel A. J. Wolff, D.S.O., and Mr. Jolly, the Research Officer of the Survey. In addition to its immediate practical objects the levelling will serve as a sure reference net-work by which to test, in future years, vertical movements of land and sea. A hundred years hence—if our successors are careful to protect the marks—most interesting information will be derived from the net-work.

In the case of the archæological work of the Survey we are dealing with a subject which attracted the interest of many of the old officers of the Department, notably General Roy. Archæology is now a fully developed science, with its own methods and generalizations, and it is increasingly bringing out, into the open, matters affecting the study of humanity and everyday beliefs and standards of conduct. Now, maps play an important part in the matter, chiefly in the way of recording accurately what has been found on the surface, or dug up, and also, in presenting the plans of the discoveries and giving correct attributions. Until recently no special steps had been taken to ensure the mapping of archæological information or the correct description of archæological objects. Much information was, it is true, shown on the maps, but much was omitted, and the descriptions were not, in general satisfactory.

To remedy this, an Archæological Officer, Mr. O. G. S. Crawford, has been appointed to supervise the archæology of the printed maps. Mr. Crawford, who is an expert well known in the archæological world, takes every map into review as it is revised, undertakes, where necessary, inspections in the field and collates the evidence. He has recently discovered many "long barrows" in Gloucestershire which were not previously marked on the national maps, and has been able to show the scheme of distribution of long barrows in South-western England. (For those who have not studied the subject it may be explained that "long barrows" were constructed by a long-headed neolithic race, at least 4000 years ago.)

I do not think that any apology is needed for putting thoroughly into order the information relating to the past which appears on the national maps. Everything on the maps must be accurate, and the maps should be made serviceable to the greatest number of people and should appeal to the greatest number of tastes. And, with regard to the staff, the more interests the Survey deals with the better. A restricted routine sooner or later leads to want of vitality.

As to the artistic side of the Survey, this is shown not only in the maps themselves, but in the map covers and advertisements. We are fortunate in possessing in Mr. Ellis Martin an artist whose work has deservedly attracted a good deal of attention. Nowadays, not even a Government Department can act on the "take-it-or-leave-it" principle, and the Survey is becoming increasingly

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dependent on the support that it receives from the general public. The public, quite rightly, looks for all-round excellence—technical, scientific, artistic.

In concluding this brief sketch of the history and of the present activities of the Ordnance Survey, I should like to leave the impression, not of an isolated Department absorbed in its own methods and history, but of a Department fully in touch with geographical effort in the Empire and the World. No officer is more welcome to the Survey than one whose experience has carried him far afield, in India, in Africa, in the four quarters of the globe. No one amongst the rank and file is likely to do so well as the man who has helped to stake out distant frontiers or to survey our remoter dependencies. We are anxious not to limit our ideas or our practice to a narrow routine. The Ordnance Survey is itself the Headquarters of the International Map of the World ; we are in touch with all the Surveys and we have all something to learn from each other. We benefit from the freshness of view that comes from variety of experience, of occupation and of idea ; and the different aspects of the work put us in touch with the Army, the civil administration, the business world, and with the realms of physical science, art and archæology. And we strive to conduct our affairs in such a way that the national survey may be a legitimate source of pride to our fellow countrymen.

References to numbers in the text :

(1) *Encyclopædia Britannica*, 11th edition, Article " Engineer."
(2) *The Ordnance Survey of the United Kindgom*, by Lieut.-Colonel T. P. White R.E., 1886.
(3) *Memoirs of the Mudge Family*, a privately printed book, kindly lent to me by Major-General Sir R. Curtis, K.C.M.G., C.B. General Mudge, the second Director of the Survey, is the officer referred to by Wordsworth.
(4) *The Ordnance Survey and the War*, a compilation issued at Southampton, 1919.

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JERUSALEM NEW WATER SUPPLY.

Compiled from a Report by Major F. W. STEPHEN, R.E., *dated 20th July*, 1918.

Existing Water Supply on British Occupation.—On the occupation of Jerusalem by the British forces in December, 1917, the water supply consisted of :—

(*a*) Water from previous year's rains stored in underground cisterns ; and

(*b*) A small aqueduct and 4-in. pipe-line from the Pools of Solomon and Urtas—length 10½ miles, fall 66 ft.—delivering water to Jerusalem, *via* Bethlehem.

Capacity and Quality of these Sources of Supply.—The total storage capacity of the cisterns in Jerusalem, ranging from those of several million gallons' capacity under the Mosque of Omar, to the small domestic cisterns to be found under or near every house, was estimated at 360,000,000 gallons. Owing to neglect in repairs and cleaning, most of these cisterns were empty, or the water in them was quite unfit for drinking. They were mostly unprotected from mosquito breeding and were thus a serious menace to health.

The Pools of Solomon-Jerusalem piped supply was part of a very ancient system which by means of aqueducts had, probably at the time of the Roman occupation, supplied the city with as much as 1,000,000 gallons per day. All that now remained was the old aqueduct from the Pools of Solomon, leading to Bethlehem and Jerusalem, along which an earthenware pipe had been built into the once great ruins. This supply had been maintained by the Turks, and the delivery from the various springs was estimated to total 80,000 gallons per day, of which 40,000 gallons were drawn at Bethlehem and 40,000 gallons were delivered at Jerusalem. Here the water was supplied to :—

(*a*) The Birket el Sultan, an artificially dammed storage of foul water ; and

(*b*) To the cistern storage in the Haram Aria (Mosque of Omar), which was comparatively clean.

Reasons for Providing a New System.—After the British occupation

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the Army consumed the whole of the piped supply for drinking purposes, and large quantities of the cistern storage for animals. The civilian population, estimated at 50,000, was watered entirely from cistern water of doubtful quality, and the reserves, which would otherwise have been accumulating in the rainy season, were becoming rapidly depleted. The rainy season lasts from November to the middle of April, during which the average rainfall is 60 cm., ranging from 90 cm. maximum to 45 cm. minimum. It was evident that immediate steps had to be taken to ensure against a serious shortage during the coming summer.

The Chief Engineer, 20th Corps, whose area included Jerusalem, instructed his Field Engineers early in January to make immediate investigations for a new supply.

Preliminary Investigation for New Supply.—The probable sources to be tapped were well known, as, under the Turkish *régime*, scheme after scheme had been got out, only to die a natural death when it reached the stage of actual construction.

From north, east and west available supplies were ruled out owing to levels and the enormous pumping schemes consequently involved.

From the south the nearest supplies, those at Solomon's Pools, were already tapped. The next supply of any magnitude was in the Wadi Arrub on the Jerusalem-Hebron road, at 22 km. from Jerusalem.

In the Wadi Arrub the water appeared to flow from several spring-heads, and ran down the valley in an open stream, from which it was principally used to irrigate small patches of cultivation. Further investigation, however, showed that the so-called spring heads were connected by an ancient system of underground aqueducts, which finally led the water into a large reservoir or "Birket" lower down in the valley, about 1050 metres to the east of the main road. This old Birket was supposed to date back to the time of Herod, B.C. 4, and at that time formed part of the main supply of Jerusalem, feeding the Pools of Solomon by an aqueduct which had been long since disused and in some places had quite disappeared. The bottom of the Birket Arrub stood at 2723 ft. above sea-level and the Jaffa Gate of Jerusalem 2618.

In January the yield of these springs was gauged at 14,000 g.p.h., and was considered capable of increase by careful cleaning.

On the 14th February, 1918, the preliminary investigations had been completed; a line of levels had been run from the ancient Birket to Jerusalem and a scheme to deliver 250,000 gallons a day was submitted to the Engineer-in-Chief on 18th February. It was proposed to repair the Birket and to pump water from there into a new reservoir at the 19th kilometre on the Hebron road, at a level of 3,085 ft., from which it would run by gravity to a second new

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reservoir on the Jaffa road, outside Jerusalem, at 2,788 ft., whence it would be distributed as required.

Scheme as Finally Approved.—The scheme as finally approved was as follows and was governed chiefly by the machinery and piping available in the country :—

(*a*) To develop and collect the water from the springs and use the ancient aqueducts to convey the water to the ancient Birket, where 4,000,000 gallons' storage could be provided. This entailed the excavation, clearing, partly re-building and re-roofing of 1,100 metres of aqueduct and considerable repairs to the old Birket.

(*b*) To erect a three-throw ram pump of a capacity of 15 to 20 thousand gallons per hour against a head of 410 ft., with two 66 h.p. Hornsby engines in a pumping station adjacent to the Birket, so arranged that water could be pumped direct from the aqueduct leading from the springs, or from the Birket storage, as required. This latter provision was made so that, should the yield of the springs diminish during the dry season, all the output of the springs should be caught in the Birket during the time that the pumps were not actually running, thus not only having a 4,000,000 gallon storage in reserve but taking full advantage of the total yield of the sources of supply.

(*c*) To lay a twin 6-in. rising main from the pumping station to a reservoir situated at kilo 19, Hebron road, a distance of 3320 metres, with a difference of level of 351 ft. It was necessary to twin this main in order to shorten the hours of actual pumping to 12 to 16 hours per day. No larger diameter pipe was available.

(*d*) To build a reservoir of a capacity of 300,000 gallons on the natural watershed about kilo 19, Hebron road, in such a position that a natural gradient would be obtained, and water would be delivered to Jerusalem entirely by gravity. This reservoir to be of masonry, and to be built of two equal compartments, and completely enclosed.

(*e*) To lay a single 6-in. pipe from kilo 19 reservoir to a point in Jerusalem situated for position and level to feed the distribution system in Jerusalem by gravity. The length of the line is 20,350 metres.

(*f*) To build a reservoir of 200,000 gallons' capacity at Lifta, on the Jaffa road, Jerusalem, at an altitude of 2,788 ft., or 295 ft. below the level of the kilo 19 reservoir. This reservoir to be of the same type as the kilo 19 one and to be completely covered in.

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(*g*) To lay the nucleus of the distribution system in Jerusalem, with a ring main capable of dealing with the maximum delivery of the gravity main in 12 hours. This system to include branches to all Army supply points, and a certain number of civilian watering points in districts where there was likely to be a shortage during the summer months. The total length of main on the original distribution system was 11,500 metres.

Instructions on the Laying of the Line.—The following instructions were issued on the laying of the line :—

(1) The line will be marked with iron kilo posts numbering from Jerusalem reservoir. Half-kilos to be marked with red-painted L.W.E. posts.

(2) Screwing parties will work from the half-kilos, and sections will be coupled up with expansion joints, so that each expansion joint will come at the kilo post.

(3) Scour valves will be placed at all the " dips," and will consist of 6-in. tee reducing to a 3-in. valve. The valves will be turned downwards and suitable pitched channels will be built under the valves.

(4) Air valves, ¼-in. piping tapped into the nearest socket, will be placed at each peak, and will afterwards be protected by locked chambers as heretofore.

(5) Sluice valves will be placed immediately adjacent to the expansion joints at kilos 4, 8, 12 and 16.

(6) A tee will be placed about kilo 3½ (exact position to be given later). This tee will have one reflux valve immediately north of it. The object of this is to have an emergency fire service for the Main Supply Depôt.

(7) The line at kilo 3 to kilo 5½ and kilo 8½ to kilo 9½ is subjected to very high pressure—about 600 ft.—and care should be taken in screwing the pipe at these points, and all pipes and fittings should be examined.

(8) Preliminary washing out will be done at expansion joints.

(9) The preliminary covering will be 1 ft. deep ; final covering 2 ft. deep. Where banks and cuttings will permit, the pipe should be kept to one side, preferably the side furthest from the Bethlehem road, to allow of a foot patrol.

(10) The pipe is all American except 5½ kilos, which are English. The English pipe will be laid where pressure is lightest, *viz.*, kilo 15 to kilo 20½.

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Carrying Out the Work.—Owing to severe weather and shortage of labour and transport the work did not commence until 12th April in Jerusalem and 15th April at Birket Arrub. Water was delivered into Jerusalem on 18th June.

The work was carried out by the following method :—One party of Sappers and local labour was employed on setting out the main pipe line and building profiles. After careful reconnaissance the final line was set out and profiles were built or dug at 20 metre intervals. This occupied 15 days. Starting ten days later, two parties, one of Egyptian Labour Corps and the other of contract labour, carried out the formation of the pipe-line, building culverts, etc., one party doing the first 15 kilos and the other $8\frac{3}{4}$ kilos. The formation was 2 m. wide on top, slopes $1\frac{1}{2}$ to 1, and drainage culverts placed where necessary. This work occupied 34 days.

Starting five days after these a party of E.L.C. and local labour laid the following distribution mains in Jerusalem :—

$2\frac{1}{2}$	kilos	...	...	... 6-in. main
$2\frac{1}{2}$	,,	...	...	... 4-in. ,,
$6\frac{1}{2}$	,,	...	...	... 3-in. ,,

The laying was difficult owing to traffic and rock excavation where it was not possible to use explosives, and the work occupied 58 days.

The work of clearing and repairing the feeder aqueduct, building the first half of the kilo 19 reservoir, the engine-house and suction-sump was begun on 15th April by E.L.C. and local labour and finished on 13th June. The investigations and clearing of the old system of aqueduct had to be undertaken with great care. All the aqueducts were partially cleared, but about one-third of the work of excavating and recovering them still remained to be done. The reservoir was built in lime mortar. The suction sump enabled the pumping to be commenced before the ancient Birket was restored.

The first half of the Jaffa road reservoir was begun on the 5th May by E.L.C. and local labour and completed on 14th June. A considerable amount of rock excavation was done in the foundation of this reservoir. Stone was quarried on the site and the masonry was built in 6 to 1 cement mortar.

On the 1st May commenced the tractor distribution of the 6" pipes, of which there were 5,000, weighing 750 tons. Twelve tractors were employed and the work was finished on the last day of the month. Originally it was estimated that five tractors would do the work in 30 days, but as they had to travel over metalled roads a further seven were allotted.

On the 14th May parties of E.L.C. began placing the pipes on formation, screwing and preliminary covering of the 6-in. mains. In some cases carries of as much as 3 kilos by the E.L.C. were

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necessary, chiefly owing to the line following the Wadi Biar a considerable distance from the metalled road. The work was completed by 10th June.

On the 15th May the erection of the 3-throw pump and two 66 h.p. Hornsby engines was begun by Sapper labour and was completed by 13th June. The pump was requisitioned in Cairo. Certain structural alterations were necessary and were completed before delivery at the site. The 66 h.p. engines came from the original pumping station at Mazar.

The 17th June was employed in washing out and coupling up, and water was delivered into the Jaffa road reservoir at 18.45 on the 18th June.

Tests.—The pump delivered 15,000 g.p.h. against a head of 400 ft. The reservoirs were satisfactory and no leak occurred. The gravity main delivered 12,500 g.p.h. to the Jaffa road reservoir, or 25 % in excess of the calculated discharge.

The distribution system at every point was up to the calculated discharge and was being rapidly extended at the date of the report.

Instructions for Completion and Maintenance.—The following further instructions were issued :—

(1) *Covering.* The final covering will be completed to a depth of 2 ft. over pipe ; 2 ft. wide at top, and 1½ to 1 slopes, stone pitched where necessary.

(2) *Anchorage.* Anchorages built in masonry will be placed on all slopes over one in ten, two in each slope, *viz.* :

kilo 2¼ to 2½, two ; kilo 13½ to 13¾, two ; kilo 14¼ to 14½, two ; kilo 2½ to 2¾, two ; kilo 13¾ to 14¼, two ; kilo 14½ to 14¾, two.

Ten of these were made in workshops, the two others were indented for.

(3) *Road Crossings.* All road crossings will be banked to 2 ft. over pipe and ramped to 1 in 20 either side of pipe line, stone pitched where necessary.

(4) *Protection of formation.* Where natives are found to use the formation as a track, stone walls will be built over the covering at intervals, as obstacles.

(5) *Drainage.* Where the drainage is considered to be insufficient, such as between kilo 1½ and kilo 2½, additional culverts will be built before the rains.

(6) *Kilo Posts.* Kilo posts will be built in dry stone with number stone let in in face indicating kilos and half-kilos.

(7) *Expansion Joint Chambers.* With the exception of those in rising main kilo 20½ to kilo 23¾, these will be built in dry stone, roofed with flat stones of suitable size.

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(8) *Scour Valve Chambers.* When all scour valves are fixed they will be enclosed in locked chambers as shown in drawings.

(9) *Air Valve and Line Valve Chambers.* When fixed, these will be built in vertical chambers with a standard 2-ft. manhole cover and locked.

(10) *Kiloage of Valves, etc.* Kiloage of all valves and expansion joints to be measured and clearly indicated on the plan and section.

(11) *Repair and Patrol Stations.* These will be established :—

(i) At Jerusalem.

(ii) Solomon's Pools.

(iii) Birket Arrub Reservoir.

Repair sets to standard list (Appendix A) will be kept at these stations. Patrols consisting of one E.L.C. pipefitter and two E.L.C. natives will traverse the section daily, outwards before 1200 and back after 1200. They will carry keys of valve chambers, caulking tools and materials, spanners, picks and shovels.

(12) *Reports.* Reports will be sent to Works Office as to "all clear" or otherwise, each night, from Jerusalem and Birket Arrub stations, and within 24 hours from centre station. Weekly reports on condition of line, and list of station equipment, to this office on Wednesday evenings.

Appendix A.

Equipment of Patrol Stations.

Pipe wrenches, 6 in.	5
Pipe cutters, wheels, 6 in.	2
Expansion joints, complete with packing	2
Chisels, hand flat	6
Chisels, hand	6
Hammers, hand	4
Caulking tools	6
Spanners, adjustable	4
Lead wool	50 lbs.
Red lead	50 lbs.
Picks	10
Shovels	10
Fosses	10
Baskets	20

Appendix B.

Personnel of Patrol Stations.

Sappers, 3 ; E.L.C. pipefitters, 3 ; E.L.C. labourers (minimum), 6.

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APPENDIX C.

Procedure in Case of a Complete Pull-out or Burst Pipe.

(1) Runner to be dispatched to kilo "o" Reservoir with report.
(2) Line valves both sides to be closed.
(3) In case of (*a*) Pull-out—
Pipe socket to be cut off or pipe cut close to socket and expansion joint fixed.
In case of (*b*) Burst pipe to be replaced—
New pipes cut to give three inches clearance between pipe ends, and expansion joint fixed.
(4) Open line valves.
(5) Dispatch runner to kilo "o" Reservoir to report "all clear" and return with message that supply has been resumed.

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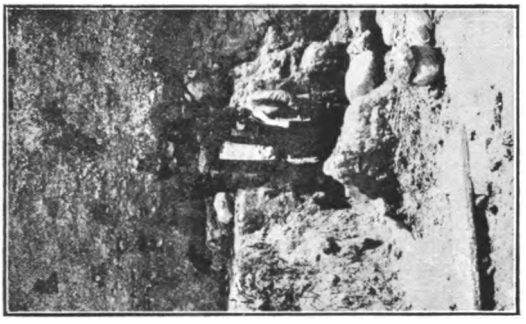
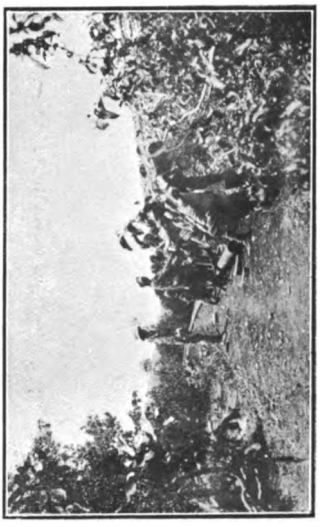
JERUSALEM NEW WATER SUPPLY.

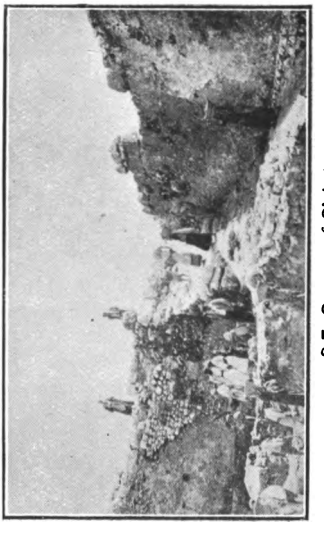


Old Sluice Gate Birket.

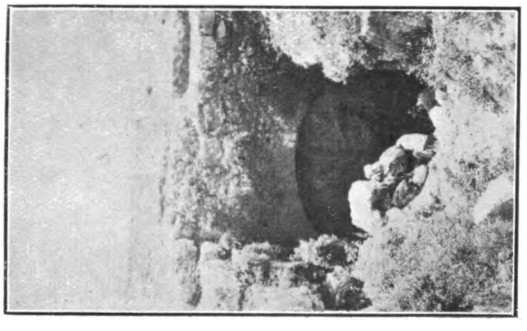


E.L.C. Screwing Party K10½

Uncovering Old Aqueduct.



S.E. Corner of Birket.



Main Spring Head.

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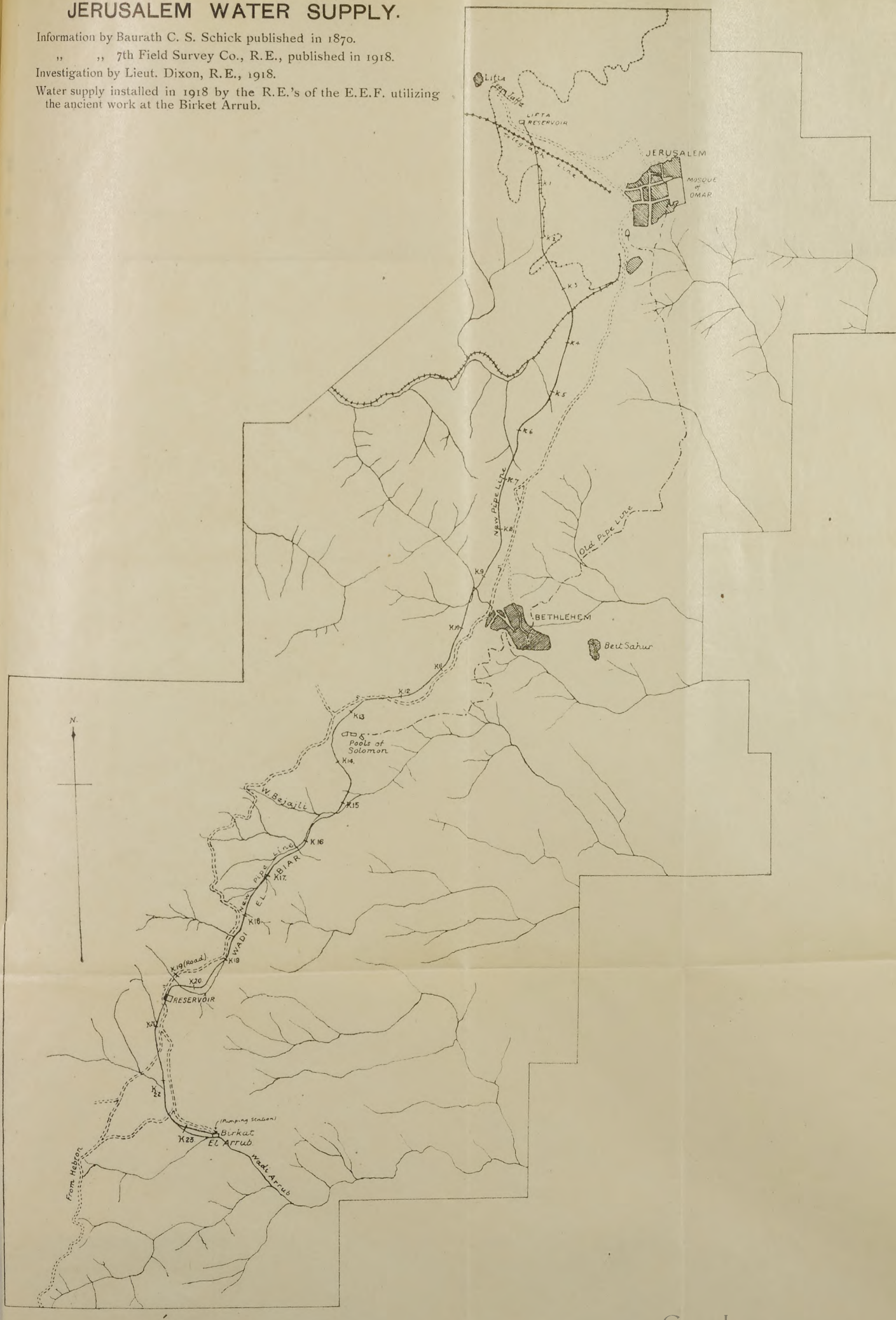
JERUSALEM WATER SUPPLY.

Information by Baurath C. S. Schick published in 1870.

" " 7th Field Survey Co., R.E., published in 1918.

Investigation by Lieut. Dixon, R.E., 1918.

Water supply installed in 1918 by the R.E.'s of the E.E.F. utilizing the ancient work at the Birket Arrub.



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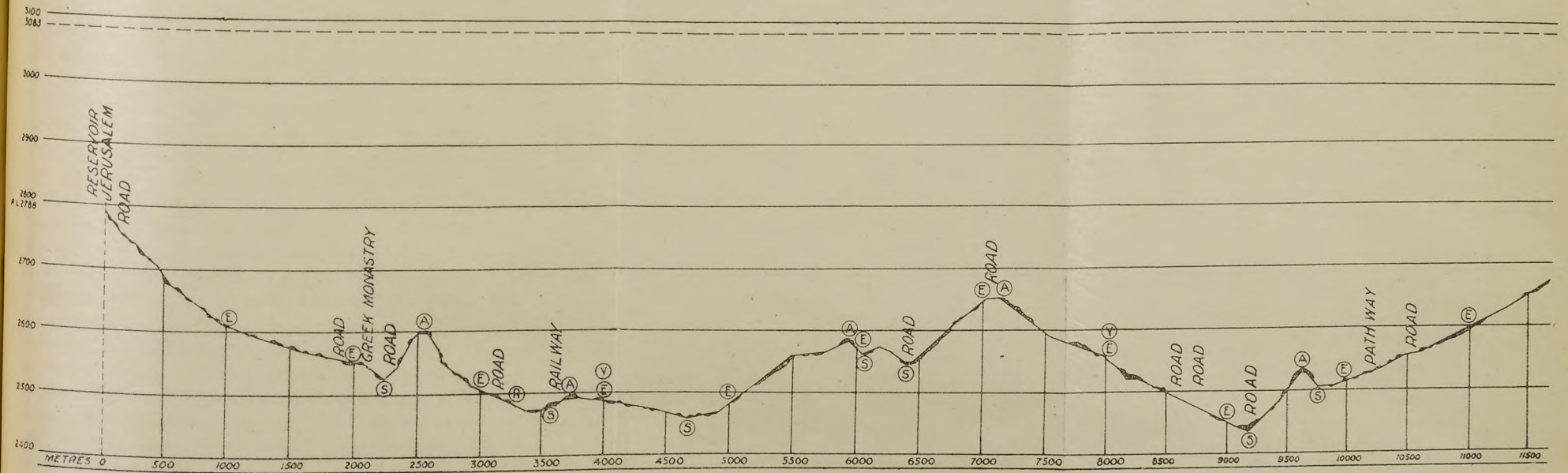
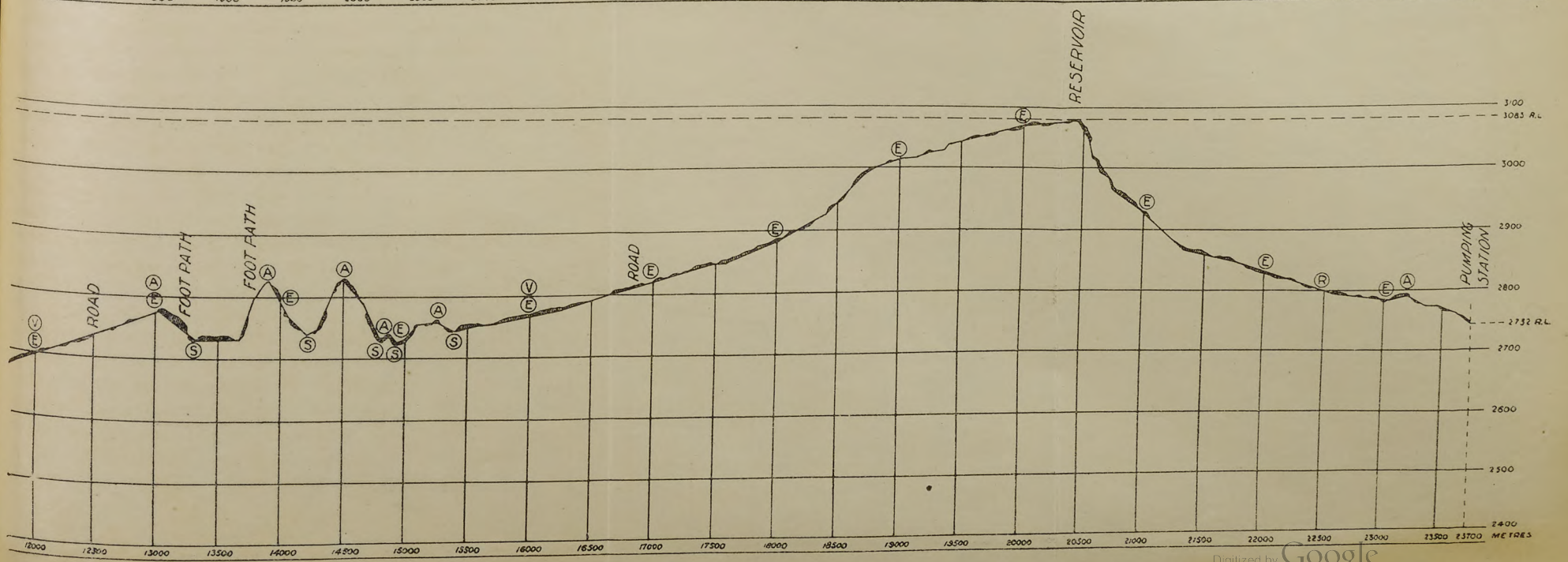
JERUSALEM WATER SUPPLY.

SECTION FROM JERUSALEM RESERVOIR TO PUMPING STATION.

SCALE — VERTICAL — 1 INCH · 100 FEET
HORIZONTAL — 1 INCH · 500 METRES.

Ⓐ DENOTES AIR VALVES.
Ⓢ " SCOUR VALVES.
Ⓔ " EXPANSION JOINTS.
Ⓥ " SLUICE VALVE.
Ⓡ " REFLUX VALVE.





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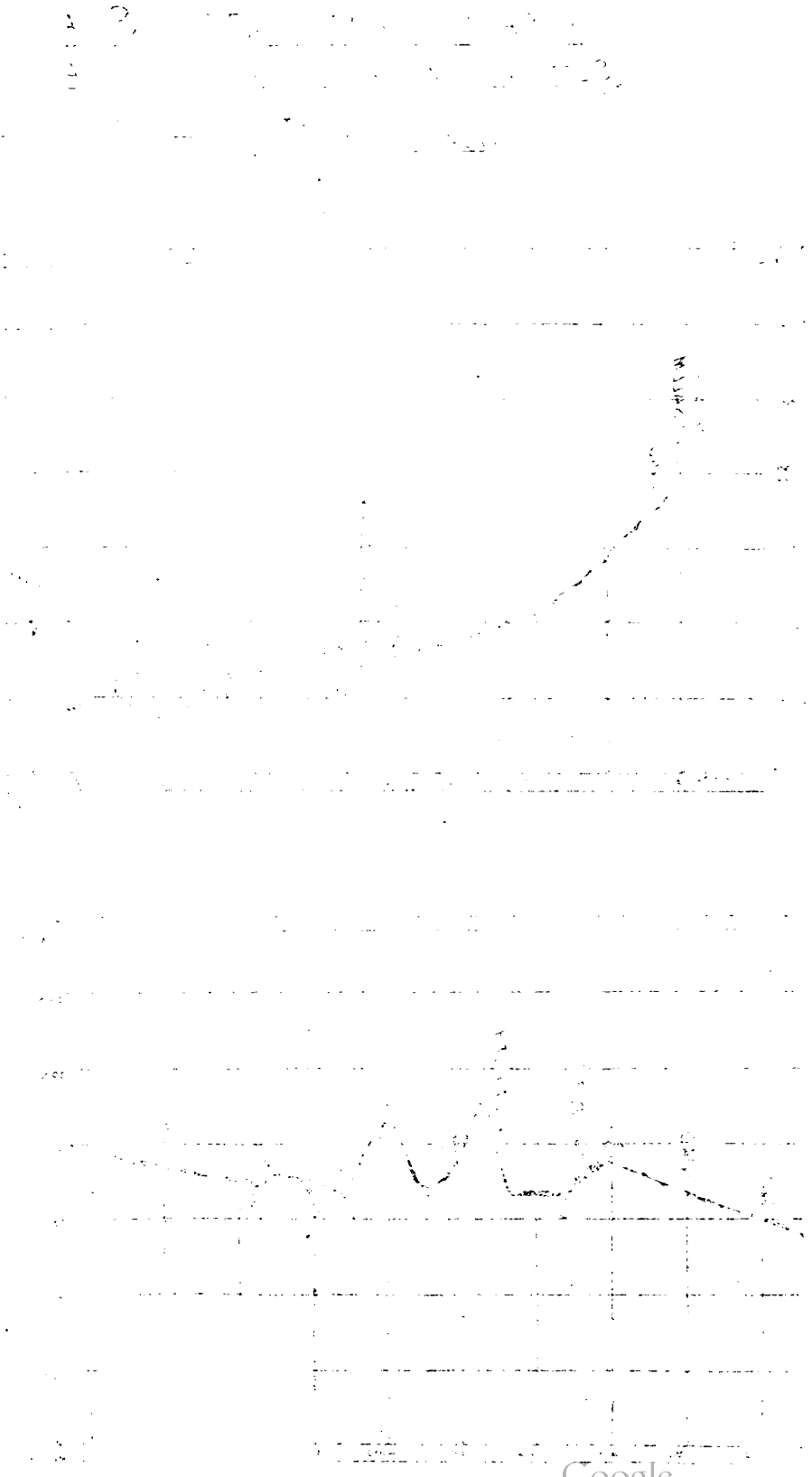

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THE EVOLUTION OF INTERCOMMUNICATION IN FRANCE, 1914–1918.

By Major R. E. PRIESTLEY, M.C., Royal Corps of Signals (R. of O.).

THE evolution of Signal Service policy, organization and practice in France during the fateful years 1914 to 1918 was undoubtedly on a par with that of any other branch of the army of first importance. The intercommunication system of an Army is equivalent to the nervous system of an organism and is just as vitally important. Paralysis of an Expeditionary Force of modern dimensions will follow just as surely on signal inefficiency or disaster as will paralysis of the human body when the main trunks of the nervous system have become diseased or have been severed. An equal similarity exists between the relative simplicity of the nervous system of a generalized organism low down in the genealogical tree of life and the signal system of an army of mediæval times, while the complexity of the nervous system of the higher vertebrates is paralleled by that of the intercommunication service of the highly specialized army of a civilized nation of the twentieth century. An observer, ignorant of the facts of 1914–1918, confronted with the signal system of an army of six divisions in the former and in the latter year, might well be excused for wondering at the multiplication of men, methods, and instruments included in the establishments of the latter.

In 1914, the Expeditionary Force was served by a relatively simple system of field telegraph and dispatch riders. The telephone was almost unused for speech forward of G.H.Q.; wireless telegraphy was completely reserved for the maintenance of intercommunication between G.H.Q. and the independent cavalry and between the major formations of the latter. The spark wireless stations in use were of an elementary type much subject to engine trouble and, as the sequel proved, much too powerful for the ranges to which their employment was to be restricted throughout the war on the French front. Continuous wave wireless—in 1919 the backbone of the intercommunication system of the Army of the Rhine—was not within measurable distance of being applied to army purposes at all.

During the mobile warfare of the autumn of 1914, this skeleton organization, eked out by *liaison* officers either mounted or travelling in cars and reinforced by visual near the fighting line, proved sufficient to meet the essential needs of a highly trained Corps of Officers. Superfluities of intercommunication naturally had to be dispensed

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with, but this was only in accordance with the intentions of the General Staff. During the retreat from Mons, the advance to the Aisne, and through the First Battle of Ypres, dispatch riders by day and telegraph by night successfully ensured a necessary minimum of signal touch throughout the higher formations.

The inception of position warfare, however, with the rapid development of intensive artillery action and consequent perfection of defences to withstand the impact of shells, almost completely robbed the situation of the features to which the pre-war signal establishments had been quite well adapted.

The essential difference as affecting "Signals" was the slowing down of the action of battle until months of preparation and fighting were required to achieve the amount of movement which in previous wars, and in the early days of this war, had been the result of a day or of two or three days at most. Armies became pinned to fixed lines of defences ever increasing in complexity and impregnability. Gunners had time to pay particular attention to communications of all types. Staffs had leisure to think out elaborate combinations requiring a multiplicity of orders, situation reports and returns. Hand in hand with this increase in complexity, marched an increase in size of the forces engaged, as the conflict changed from the business of a professional army to the main object of existence of the manhood of the nation. To officer such monstrous armies as were slowly but surely coming into action overtaxed the resources of the Regular Army. The consequent falling off in the efficiency of Staff and regimental officers was reflected in a multiplication of orders. Especially was this seen in the necessity both for means of more personal intercommunication (the telephone) permitting of detailed explanation, and of safer means of transmitting written messages even to the most forward executive officers in or near the trench lines.

It is to this change from mobile to stationary warfare that almost all the technical evolution of the Signal Service must be attributed. A short sharp campaign might have left the intercommunication system much as before the war. Indeed, it is difficult to imagine how any great change in technique could have been brought about without the intervention of the adequate time element provided by the deadlock which was the feature of the war on the Western front between December 1914 and June 1918.

In a short summary like the present it is, of course, impossible to treat in detail the changes which had such an immense cumulative effect. Considered broadly, however, three separate but interdependent lines of evolution can be detected which brought about respectively the present organization, the present practice, and the present policy, of the Corps of Signals.

Of these three, the first two belong essentially to the period of Position Warfare; the last was worked out in theory during the more

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extended of the offensives of 1916 and 1917, but was naturally not finally sealed until its wisdom had been proved in the mobile warfare of 1918. Decisive warfare is necessarily mobile warfare. It is to the fact that the Directors of the Signal Service bore this in mind throughout the long-drawn-out stationary phase of the conflict, that much of the permanent value of the dispositions and changes then made is due. A rigid, crystallized, unadapted intercommunication service could not have coped successfully with the advance of the autumn of 1918. It certainly could not be expected to conform rapidly and efficiently to the environmental conditions of such a campaign as the advance through Palestine, nor to the normal course of warfare on the frontiers of Empire which is the "peace-time" avocation of the Regular Army.

The outstanding features of the evolution of signal organization during the war may be summarized as follows.* The attention of the signal higher command was first directed towards the removal of a certain looseness of organization which had been a distinct drawback to the pre-war Signal Service as seen working during the first few months of the war. The creation of a chain of command within the Service itself was a *sine qua non* if efficiency was to be obtained. Good end in itself though this was, a far-sighted policy soon combined it with the attempt—successful in 1916—to convert the senior signal officer of each of the higher formations from an executive officer at the orders of a Staff who could not be expected to understand fully the possibilities and limitations of a complicated signal technique, into a true Signal Adviser to his General, with the status of a Staff Officer of high rank. The creation of the positions, D.D. Signals, Army, and A.D. Signals, Corps, with the rank of full Colonel and Lieut.-Colonel respectively, was undoubtedly a victory fraught with more good to the Signal Service than any other single reform carried out during this critical period. It was this preliminary step which largely made possible the alteration in signal establishments which was the other outstanding feature of signal re-organization in this year.

Until after the Battle of the Somme (1916) various considerations —for instance, the scanty supply of trained reinforcements, the rapid development in signal technique which characterized position warfare, and, especially, the pressure of the war itself—prevented any

* For detailed information as to the work and evolution of the British Signal Service in France from 1914 to 1918 the reader is referred to the volume "History of the Signal Service in the European War (France)" now published under the auspices of the Institution of Royal Engineers and the Publications Committee of the Signal Service Association. It is hoped that circumstances will later permit of the publication of a companion volume, already partly prepared, which will deal with other fronts.

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more than temporary adjustments of signal establishments to meet the new conditions. In the winter of 1916–1917, however, all these sources of inertia were overcome and the position warfare signal service was officially approved, the new establishments being made up to strength in time for the spring offensive of 1917. The features of the reorganization were, the additional of personnel for local regional maintenance (" area " personnel), great increases to artillery signal units (the Signal Service was now entirely responsible for the intercommunication of artillery formations), and the creation of several technical trades not formerly existent. Here are seen the direct reactions to (1) relative immobility, (2) artillery domination of the situation, and (3) an advanced signal technique which will be referred to later. The forward movement of technical qualifications towards the lesser units in the immediate battle line was throughout a feature of signal development during the war.

Perhaps more important even than the changes which did take place in this " First Great Reorganization " were those that were left undone. The Signal Directorate set its face steadily now and hereafter—in the face of many obstacles—against any decrease in the mobility of the essential intercommunication units of Armies, Corps and Divisions. The wisdom of this policy was to be seen in the success of the remodelled Signal Service in the comparatively mobile warfare of 1918.

Intimately interlocked with this question of reorganization was that of changes in signal practice. Position warfare, while it made complicated intercommunication schemes desirable and possible, made all intercommunication difficult, costly of life and material, and, at times, extremely unreliable. The barrage was as efficient at destroying forward lines as advancing infantry. High explosive long-range fire battered to pieces not only the signal routes, but the nodal points of the ganglia of the human nervous complex. Reaction to these stimuli took many forms. The two most important were perhaps, (*a*) the multiplication of means of forward signalling and (*b*) protection of forward line routes. From the latter, again, sprang the policy of concentration of signal responsibilities along definite main channels which was another great step forward in the evolution of a definite signal policy.

The first great reaction between the means of signalling employed and the position warfare environment was the wholesale introduction of the magneto telephone for forward signal work. This took place in 1915 and was the direct result of the cessation of movement. From it was to spring the overhearing menace which in itself gave rise to a special department of Intelligence, to special highly technical instruments, to distinct new means of signalling involving earth telegraphy, and which finally stultified the forward telephone system.

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The first main effect of the increase of forward telephone communication was, however, the multiplication of lines at the time of all others when they were likely to cause most trouble to all concerned. A welter of lines of every description, running in all directions, many of them laid, cut, and abandoned in a few hours, threatened to bring an overburdened Signal Service into lasting disrepute. This unfortunate consummation was only avoided by the evolution, first of the shallow bury, and later of the deep 5·9-proof bury. Before the end of 1916, the latter had brought about the replacement of an insecure network of field and trench cable by a more or less orderly "grid" of safe main-line route from the front line to the rear limit of the "zone of frequent shelling."

Before this result had been achieved, however, the unsafeness of the line system had been emphasized in a manner not likely to be forgotten. The immediate result was the rehabilitation of Visual and its rejuvenation through the invention of improved and less easily "overseen" instruments. The transference of an efficient Pigeon Service from the Intelligence Branch of the General Staff to the Signal Service and its development to a size undreamt of by its originators followed. Finally yet other alternative means of intercommunication were perfected by the evolution of wireless telegraphy and its adaption to trench warfare and by the training and organization of runners on a larger scale than ever before.

Later came the Power Buzzer and Amplifier as the results of experiments on overhearing, while the Fullerphone, developed as a countermeasure to the same menace, gradually (in 1917 and 1918) ousted the forward buzzer and telephone from their former monopoly.

Comparatively early in the war, the clumsy vibrator of 1914 days had been replaced at all Formation Headquarters by the more efficient and less nerve-racking Sounder.

From 1916 on, when the various alternative means of signalling had become practicable rather than experimental, the great tussle began between "line" signalling and other methods not dependent for their efficiency upon the continuity of a metallic conductor, between Headquarters in the Battle Zone. Safe buried line routes were always the backbone of a stationary warfare system. In attack and retreat, on the other hand, the Lucas lamp from heavily protected emplacements; the wireless set with inconspicuous aerials; the Power Buzzer with short earths buried in tunnels or in deep trenches and instruments hidden in impregnable dug-outs; the pigeon with its straight flight through untainted air; survived where lines were often blown to pieces, impossible to maintain, or even, sometimes, to lay. The successful signal officer was he who best disposed his men so as to make full use of alternative chains of at least two or three of the above means. Signals in position warfare became more and more a matter of organization. The forward signal officer

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reduced to the employment of runners as his sole means of intercommunication had to admit that, for the time being, he was a rather costly failure, though under certain sets of circumstances such a temporary failure was unavoidable.

While 1915 was the year marked by the evolution of these alternative methods, 1916 saw their combined employment in somewhat haphazard schemes whose main fault was perhaps the overtaxing of the available personnel by the utilization of too many means along too many routes from front to rear. Yet these schemes were oftentimes successful and carried within them the germ from which the future policy of the Service was to be evolved. The experience of this year was not lost. In 1917 came the standardization of forward signals along a single route in each fighting formation. The publication of the two Staff Manuals for Intercommunication in Battle gave the signal officer an authoritative backing which proved to be of incalculable value. The publication of S.S. 191, in particular, crystallized, and brought within the reach of everyone concerned, the greater portion of the knowledge about intercommunication which had been gained both by the Signal Service and by the General Staff during three years of intensive warfare. Changes in details of organization, practice and policy still took place, but the main lessons had been learnt and no essential alterations were made.

Enemy long-range bombing and shelling in the autumn of 1917 to some extent forced a return to lighter and more scattered routes in the rear areas. Routes of 12 to 20 wires replaced the heavy permanent routes of 28 wires and upwards which had become more and more a feature of the countryside in rear of the buried cable "grid." This and the burying of leads in and the diversion of routes round towns and camps, added another strain to a rear intercommunication service which had grown steadily with the increase in size of the Expeditionary Force. L. of C. and G.H.Q. Signal Companies on August 4th, 1914 totalled 10 officers and 354 men. At the time of the Armistice "L" Signal Battalion, which had absorbed G.H.Q. Signal Company, had reached the startling figures of 110 officers and 4,102 men. In addition, from the beginning of the war, Signal Depôt and Signal Parks, highly organized and extensive in size, had catered successfully for the supply of technical reinforcements and stores.

Such are the broad outlines of Signal Service evolution up to the time when the mobile warfare of the spring and autumn of 1918 brought about in some degree a reversion to type. All the new signal units considered essential to a mobile system possessed the necessary meed of transport of which motor transport was an important constituent in all the higher formations. The March retreat was a severe test of signal organization and discipline, but formations retreating according to plan were accommodated on the rear line

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system or an improvised cable "grid." Even formations which were hardly pressed and sometimes lost their directions were not without means of keeping touch. The great development of wireless and visual, notably the spark and continuous wave short-range sets and the Lucas lamp, sufficed usually to meet both such extreme cases and the more normal, but, under these conditions, doubly essential, lateral intercommunication.

In the advance again, a central cable or airline route was the main stand-by of the advancing Divisions, Corps and Armies. When the rate of construction of such routes lagged behind the speed of advance, as was sometimes inevitable, wireless was again invaluable while forward of Brigade Headquarters two-way visual on an unprecented scale helped out the runners of the infantry and the mounted orderlies of the cavalry screen. Nor was the aid of aeroplane scouts uncatered for. In 1916 and 1917 these auxiliaries had been of great value to the intercommunication service. In 1918 their employment for conveying situation reports was assisted by the systematic establishment of Aeroplane Dropping Grounds at all Report Centres and Headquarters.

The adoption of a predetermined route of advance was an incalculable boon to signal officers forced to adopt rapid leap-frog tactics to keep visual, wireless and cable offices abreast of the leading battalions and Brigades. Isolated cases occurred of signal offices being set up by Divisional Signal Companies in villages yet technically in the possession of the enemy. By its marked success in this last and greatest test the Signal Service proved decisively that the correct lessons had been drawn from those essays in semi-mobile warfare which had from time to time relieved the monotony of the stationary warfare of the previous three years. The tribute paid to the intercommunication personnel in the Commander-in-Chief's last dispatch was perhaps no more significant in this respect than the fact that everywhere the relations between the General Staff and their signal officers were cordial in the extreme. An inefficient intercommunication service might undoubtedly have proved the limiting factor to the advance. That this never was the case, never even nearly the case, is positive proof that signal evolution proceeded throughout the war on the right lines and at the right speed.

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THE "LEWIS" MEDAL.

AT the Corps Meeting held on the 14th June, 1919, a very generous offer of Mrs. Lewis for the establishment of a silver medal in memory of her husband, the late Colonel J. F. Lewis, R.E., was put before the meeting and unanimously accepted. It was further decided that the conditions of award should be as follows:—

"That the medal be presented to the young officer of each batch passing through the School of Military Engineering, on the recommendation of the Commandant, for proficiency in fortification and field engineering."

Colonel Lewis was an expert in fortification, and it is, therefore, natural that the medal should be awarded for proficiency in that subject.

Owing to the exigencies of the service, the first full course of training, qualifying for the award, has only recently been completed, and the first "Lewis" medal was presented to Lieut. Ernest Bader, R.E., on 8th October, 1921.

The medal, the design of which is shown in the accompanying photographs, is the work of Mr. Frank Borscher, and was struck by Mr. John Pinches. On the obverse, it gives an excellent portrait of Colonel Lewis wearing the old R.E. frock coat, as worn in the last half of the nineteenth century by all officers of the Corps and later restricted to Field Officers only, until soon after the South African War, when the plain frock coat became regulation for all branches of the service; and over it is the R.E. cross-belt, as still worn. On the reverse is shown the Rock of Gibraltar, from the Rock Gun to Europa Light, chosen as emblematic of British fortification and also because Colonel Lewis held the appointment of Commanding Royal Engineer (now Chief Engineer), Gibraltar; it was his last station and he retired from it owing to age, in 1903.

The following brief sketch of Colonel Lewis' career is taken from the memoir published in the *R.E. Journal* of June, 1918:—

Born near Exeter, on the 14th May, 1846, Colonel Lewis passed into the R.M.A., Woolwich, in 1864, obtaining his commission in the R.E. on the 15th January, 1867; was promoted Captain on the 13th September, 1879; Major on the 15th January, 1887; Lieut.-Colonel on the 22nd May, 1893; Colonel on the 22nd December, 1898; and retired, under the age clause, on 14th May, 1903.

He re-wrote the Text Book of Fortification, *Permanent Fortification for English Engineers*, published by the R.E. Institute in September,

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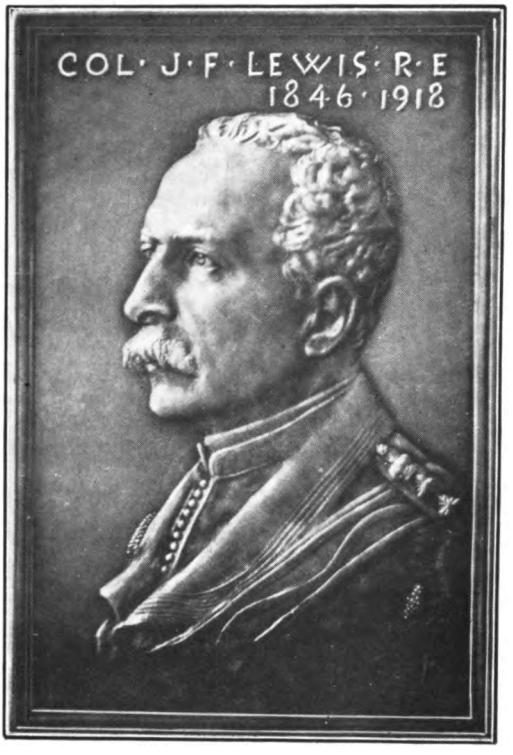
THE "LEWIS" MEDAL.



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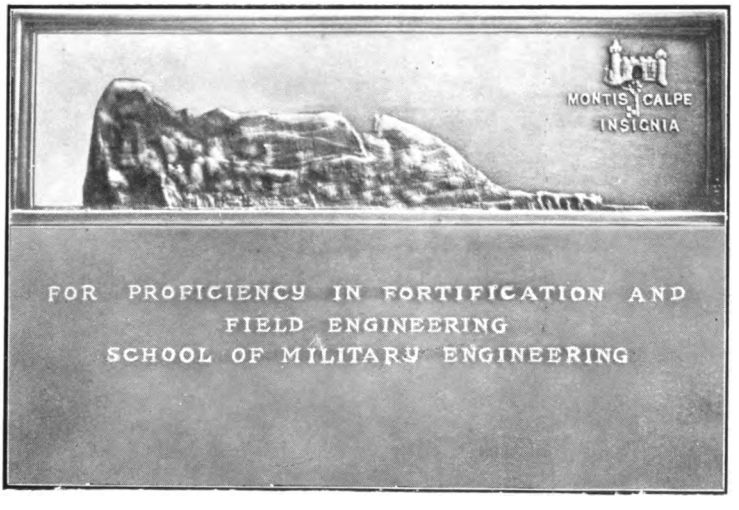

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1890; reported on the fortifications of the Island of Ascension, for the Admiralty, in 1896; and that of the Falkland Islands, also for the Admiralty, in 1896-7; and on the Defences of Wei-hai-wei, in 1898.

After his retirement he was specially appointed to go into the land question at Hong Kong, in 1905, the resulting "Lewis Agreement" being still consulted. Thence he went to Port Arthur, to report on the defences after the Russo-Japanese War.

He offered his services to the W.D. when war broke out in 1914, but, owing to his age, his offer was not accepted. He passed away on the 7th February, 1918, at his house, at Winchester.

"He was of a strongly religious character and, as was said recently of an officer who fell in France: 'He was a real noble and Christian English gentleman, than which no more can be said of any one.'"

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PROFESSIONAL NOTE.

AMERICAN PONTOON EQUIPMENT.

THE DEVELOPMENT OF HEAVY PONTOON EQUIPAGE FOR INCREASED ARMY LOADS OF THE FUTURE.

[CONTRIBUTED BY THE R.E. BOARD.]

THE following is a *résumé* of an article under the above heading, by Captain Theodore Wyman, junr., Corps of Engineers, which appeared in the September-October number of *The Military Engineer, the Journal of the Society of American Military Engineers*, and the discussion which followed it.

REQUIREMENTS OF FUTURE PONTOON BRIDGES.

The adoption for the mobile army of recently developed heavy mobile cannon, self-propelled or tractor-drawn, heavy tanks and heavy truck transportation, has necessitated the development of heavy pontoon bridge equipage, of greater capacity than the present standard equipage. Heavy pontoon bridge equipage of construction along the lines of the standard equipage, of minimum weight, and adapted to being transported readily on vehicles subject to being animal-drawn, truck-drawn or tractor-drawn, must carry safely the heaviest loads which accompany the Corps, namely, the loaded 5½-ton Mack truck, which, when loaded to capacity, has a maximum concentrated axle-load of 13,500 lbs. on the rear axle and 7,800 lbs. on the front axle, the distance between axles, centre to centre, being 13 ft. 4 in. There must also be developed a reinforced type of pontoon bridge, using the new equipage, supplemented by special materials deemed necessary to carry safely the loads which accompany the army, which recent developments of Ordnance materials indicate may include the new Christie Self-propelled Mount for a 6-in. gun, weighing 19 tons, and the Christie Medium Tank, weighing 18 tons. Extensive studies of all available records showed that the allowable weights for a pontoon equipage, readily transportable, would limit the capacity of the pontoon boat to a supporting power of 20,000 lbs. with a 9-in. free-board, and the length of the normal bay to 16 ft., which would require a superstructure consisting of seven or eight baulks of weights easily handled by two men, rigidly connected to two side rails—also road-bearers—by transverse baulks and baulk-collars, and a double thickness of 2-in. chesses.

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Pontoon Boats.

Three types of experimental boats, *viz.*, wooden, steel and aluminium boats, were designed, manufactured and tested.

The wooden boat was of the scow type, similar to the existing standard pontoon. Its dimensions were :—length, 32 ft., beam 5 ft. 8 in., depth 3 ft. 1 in., and it weighed 2,225 lbs. It was constructed entirely of wood with an oak frame and $\frac{7}{8}$ in. white pine skin.

The steel pontoon was of the boat type, of galvanized steel construction throughout, and its dimensions were :—length 32ft. 6 in., beam 5 ft. 8 in., depth 3 ft. 1 in., and it weighed 1,765 lbs. It was constructed of galvanized sheet steel, riveted to an angle-iron frame and channel-iron gunwales and was divided into four watertight compartments by transverse bulkheads, which materially strengthened the boat and increased its flotation, as it was necessary to pierce at least two compartments in order to sink the pontoon when in its position in bridge.

The aluminium pontoon was of the boat type and was constructed of aluminium skin mounted on an oak frame, of sufficient flotation to prevent the pontoon from sinking when filled with water. Its length was 31 ft. 6 in., beam 5 ft. 8 in., depth 3 ft. 1 in., and it weighed 1,635 lbs. This boat was also provided with four separate watertight compartments by means of transverse bulkheads, in order to increase its strength and carrying capacity when one or two of the compartments were punctured by gunfire or otherwise.

These boats had sufficient displacement to carry super-imposed loads as follows and allow for a 9-in. free-board :—

Wooden boat, 20,000 lbs. ; steel boat, 22,000 lbs. ; aluminium boat, 23,000 lbs.

Tests.

The tests were carried out between 3rd April and 2nd June, 1921, at Camp A.A. Humphreys, Va. In order to be as thorough as it was possible to make them within a limited space of time, they included the following general points :—Boat Tests ; Tests of the Material in a Grounded Pontoon Bridge ; Tests of the Material in the Pontoon Bridge ; and Transportation Tests.

Boat Tests.

All the boats functioned equally satisfactorily in a pontoon bridge constructed in water, and carried successfully axle-loads ranging up to and including 17,900 lbs. The Mack truck and the 10-ton Holt tractor were passed over the bridge without incident, and later both were passed over together, spaced so that the centres of the loads were located over adjacent pontoon boats. A Mack truck was loaded until its gross weight was 27,800 lbs. ; divided approximately with 9,380 lbs. on the front axle, and 17,900 lbs. on the rear axle, and then passed over the bridge. Under this load the saddle boat—the pontoon next to the trestle—was immersed until it had only 4-in. free-board, while under the same load the second boat in the bridge from the shore had 9-in. free-board. This indicated that the capacity of the saddle boat determined the maximum load which could be passed over the bridge.

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This was due to the fact that the span between the trestle and the saddle boat was longer than the normal span and also because only a small part of the load was transmitted to the adjacent pontoons. The pontoons are gunwale loaded.

A pontoon bridge of five bays was built on land with the pontoons resting on a bed of river gravel simulating the bottom of a stream. All of the experimental pontoon equipage carried axle-loads up to and including 17,000 lbs. without incident. Under a 30,000-lbs. axle-load both the aluminium boat and the steel boat commenced to fail by buckling of the gunwales. Under a 40,000-lbs. axle-load the gunwales of the metal pontoons were so badly crushed that they had to be removed. Both failed to the extent to make repair difficult. An axle-load of 46,000 lbs. was successfully carried by the wooden boat without showing any signs of failure. These tests showed conclusively that the wooden boat was superior in a grounded bridge. In view of the wide tidal fluctuations of the coastal streams of the United States, it is believed essential for pontoon boats to carry successfully the increased army axle-loads when the boats are grounded on the bottom of a river.

All three boats were readily loaded and unloaded, and none presented any difficulties when handled by a detail of 18 to 20 men. The differences in the weights of the boats made no material differences in the tractor-drawn and motor-drawn transportation tests. In a horse-drawn test all were easily hauled. All boats were easily handled in the water by crews of four rowers and a steersman, and the higher free-board presented no real difficulties in rowing. A load of sixty soldiers with heavy marching packs was readily transported in each type of boat. Under rifle fire at a range of 125 yards five shots were sufficient to put the steel boat in danger of sinking. In each case the bullet made a clean entrance hole through the near side and from two to six ragged holes through the far side. Another account says that bullets striking above the waterline made round holes much larger than the bullet, nearly $\frac{5}{8}$ in. in diameter, and bullets striking at or below the water-line tore jagged irregular holes from two to three inches across, because of the striking effect of the water itself upon the brittle steel of which the pontoon was made. Eleven shots were sufficient to flood the aluminium boat. In each case the holes through the aluminium skin, in and out, were clean and no bullet caused more than two holes. One hundred and twenty-five rounds were fired at the wooden boat without stopping to do any patching. Holes were generally clean and the water entered very slowly. The results of the rifle tests were decisively in favour of the wooden boat. However, it must be remembered that the range was only 125 yards and that at a greater range difficulties might be encountered in penetrating sufficient compartments below the water-line of the steel and aluminium boats to flood them with water. Furthermore, a pontoon bridge constructed of boats subject to being readily sunk might prove extremely advantageous during a retreat, when, due to lack of time to remove it, the destruction of the bridge might be highly desirable. A few hand grenades properly applied to the steel pontoon boat could easily accomplish this result. The bullet holes in both metal boats were readily plugged before the

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boats were filled with water, by a rubber gasket patch which consisted of a rubber washer on a wide-headed bolt provided with a wing nut. Several other types of patches were tested but did not prove adaptable to patching ragged holes in the skins of the boats.

All of the boats were equipped with four skids which proved a decided improvement and aided materially when moving boats on land and handling them in the water. All boats were equipped with a windlass located in both bow and stern, similar to that used in the German pontoons, but under tests this equipment did not present any great advantages over the mooring post now in use.

The principal argument in favour of metal boats is their resistance to time and the elements while in storage in a hot arid climate and their immediate availability for service at all times after construction. So far as availability of materials for construction and rapidity of construction are concerned, experience in the manufacture of boats indicated that the steel boat should rank first, the wooden boat second and the aluminium boat third. In general the performances of the aluminium boat under tests were superior to those of the steel boat, and the officers conducting the tests recommended to the Chief of Engineers that sufficient aluminium boats for an experimental pontoon division be procured and subjected to field tests over a long period of time. This recommendation was explained in the Discussion as follows:—It was thought that little more could be learned with respect to the wooden boat, but it was felt that the many advocates of metal would hardly be satisfied by tests so short in duration, and which could not, in fact, be called complete. Additional experiments with the metal boat were, therefore, urged to give it a better chance to recommend itself as a type, or, failing that, to hush the clamour of its champions.

Baulks.

Due to results of tests conducted by the Bureau of Standards and the Forest Products Laboratories of timbers which may be secured in large quantities, Douglas fir was selected as the material most suitable for baulk construction. Tests of baulks constructed of Douglas fir reinforced by steel plates and $\frac{1}{2}$-in. twisted steel rods, indicated the impracticability of reinforcing wooden baulks with metal. Studies indicated the impracticability of using steel I-beams for baulks due to excessive weight.

The following table shows the types of baulks constructed, dimensions and weights of same, and the loads carried by bays constructed of same. In each case seven baulks plus two side rails were used per bay.

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Type.	*Size.*	*Weight.*	*Type of Bay.*	*Axle-load under which Bay failed.*
1-Piece wooden baulk of Douglas fir, rectangular cross section	4½ in. × 6⅜ in. × 23 ft.	166 lbs.	Boat-to-boat span 16 ft. Transverse baulk used.	This bay carried 46,000 lbs. without failure.
Do.	do.	do.	Boat-to-boat span. No transverse baulk.	Failed under 44,500 lbs.
Do.	do.	do.	Boat-to-trestle span 18 ft. 10-in. Transverse baulk used.	Bay failed under 36,000 lbs.
2-Piece wooden baulk. Two pieces of Douglas fir bolted together. Rectangular cross section	4½ in. × 6⅜ in. × 23 ft.	155 lbs.	Boat-to-boat span 16 ft. Transverse baulk used.	Bay failed under 42,000 lbs.
1-Piece wooden baulk of Douglas fir, I-beam cross section	4¾ in. × 6⅜ in. × 23 ft.	146 lbs.	Boat-to-boat span 16 ft. No transverse baulk.	Bay failed under 40,000 lbs.
Do.	do.	do.	Trestle-to-trestle span 20 ft. Transverse baulk used.	Bay failed under 19,000 lbs.
Steel I-beam baulk	5 in. × 9¾ lbs. × 15½ ft.	155 lbs.	Trestle-to-trestle span 13½ ft. No transverse baulk.	Bay failed violently under 40,000 lbs.

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From the foregoing figures it is obvious that the one-piece baulk, constructed of Douglas fir of rectangular cross section, $4\frac{1}{4}$ in. × $6\frac{3}{8}$ in., is the strongest type of baulk. However, all bays made up of the various types of baulk carried successfully a loaded $5\frac{1}{2}$-ton Mack truck, a 10-ton Holt tractor, and axle-loads up to and including 17,000 lbs., without incident or excessive deflection. The figures also indicate clearly the advantages obtained from the use of the transverse baulk for partially transmitting the load to the side rails. The transverse baulk was constructed of Douglas fir, $4\frac{1}{4}$ in. × $6\frac{3}{8}$ in. × 12 ft., and was equipped with spacing cleats which engaged the longitudinal baulks. It was rigidly connected to the side rails by means of baulk collars constructed of steel. These collars consisted of two pairs of lazy tongs which opened to receive the transverse baulk and supported it when closed, and which were flexibly connected to a saddle provided with a jack-screw that rested upon and across the side rail baulk. The baulk collars tested were equipped with a cam to open and close the tongs. This refinement proved unnecessary and it is believed that a simplified design will provide a strong and flexible means of lashing the side rails, chesses, longitudinal and transverse baulks firmly together. The baulk collars may be quickly installed from the bridge floor.

All of the baulks tested were equipped with steel pins which engaged in baulk-pin sockets on the pontoons, thereby providing a positive though flexible connection between baulks and boats and also eliminating the temporary lashing now made when laying baulks in place. The retention of the baulk-pin is favoured. It did not present any difficulties when stacking the baulks in piles or transporting them on wagons. In addition to the baulk pin connection, the baulks were lashed to the boats by means of the standard $\frac{1}{2}$-in. lashing, to prevent movement in the vertical plane only. Numerous studies were made of designs for mechanical lashings which in most cases were a mechanical contrivance located on the baulk, thereby precluding an adjustable length of bay. The aluminium boats were equipped with a mechanical lashing consisting of a strap constructed of brake-lining material, one end directly connected to the gunwales and the other end adjustably connected by means of a ratchet device and adaptable to lashing the baulk to the boat at any point along its length. However, under test they proved cumbersome and unreliable and presented no advantages over the rope lashing now in use.

The boats were provided with lashing hooks. However, it is believed that a waling piece fastened to the inner sides of the ribs of the boat, about 6 in. below the gunwales, would provide a more suitable means for lashing baulks at any location throughout the width of the roadway.

In order to make all pontoon boats identical as to the lay-out and location of the baulk-pin sockets, it is necessary to lay the baulks with a slight slant, or at an angle whose offset from the centre line of the bridge equals the width of the baulk. It would be impossible to lay the baulks parallel to the centre line of the bridge unless three alternate baulk-pin sockets are provided for each baulk location. Another advantage gained by the angular method of laying baulks applies to

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the side rails of the bridge. When the side rails are laid in this manner, the inside roadway end of the baulks pointing towards the far shore on the right-hand side, no projecting baulk ends are in a position to be struck by, or to interfere with, traffic which bears to the right in the usual manner.

CHESSES.

The chesses were constructed of white pine on account of its lightness, $1\frac{1}{16}$ in. thick, by 12 in. wide, by 12 ft. long. A length of 23 in. at each end was reduced to a width of $10\frac{1}{2}$ in. and reinforcing rivets of $\frac{1}{4}$-in. steel were riveted through the chess $1\frac{1}{2}$ in. and $21\frac{1}{2}$ in. from each end to prevent the chess from splitting. Its weight was 43 lbs. A double thickness of chesses was used on the bridge tested and proved to be the weakest element. The white pine was badly crushed under the wheels of the heavy loads and in many cases the loads cut through the double layer of chesses when the wheels were not located directly over a baulk. These tests indicated that white pine is no longer adaptable for the construction of chesses intended to carry the increased loads, and studies of the possibilities of longleaf Georgia yellow pine, maple and oak, for use as chesses, are being made. The width of the roadway of the bridge tested was 9 ft. 6 in., but later developments proved the necessity for a bridge with a 10 ft. 6 in. clear roadway. This increase will undoubtedly require eight baulks per bay in order to decrease the chess span between baulks to a minimum.

TRESTLES.

Two types of trestles were designed, manufactured and tested. Type No. 1 trestle was constructed entirely of structural steel and Shelby cold-drawn tubing. It consisted of two threaded steel columns that adjustably supported, by means of capstan nuts, housing and clamp members, a 9-in., 21-lbs. I-beam transom, together with its reinforcing members. The entire transom unit could be raised, lowered and clamped in place from the roadway of the bridge by two men. The trestle consisted of seven separable units, the transom, two struts, two columns and two trestle shoes, and weighed complete 1,090 lbs. In order to strengthen the transom, its unsupported span of 12 ft. was reduced to 8 ft. by the use of two struts of 3-in., $5\frac{1}{2}$-lbs. I-beams, 2 ft. 8 in. long, used as diagonal braces. When the transom and its struts were placed in their respective housings and the suspension members and cross-guide rods were tightened to their home positions, the entire assembly became a complete bridge panel, adapted to be supported by its two side columns and trestle shoes. The trestle shoes had approximately 4 sq. ft. of area and were constructed of wood, reinforced with angle-iron around the bottom edge and across the bottom face, and equipped with steel teeth projecting downwards to prevent side-slipping. The connections between the shoes and the columns allowed the shoes to accommodate their positions to inequalities of the foundations without disturbing the vertical position of the side columns.

Type No. 2 trestle consisted of a lattice angle iron transom slidingly adjustable along its two end supporting steel columns by means of

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chain hoists supported by the upper ends of the side columns. The transom was supported in place by pins that passed through the end plates of the transom and corresponding holes in the columns. The trestle consisted of seven separable parts, transom, two columns, two chain hoists, and two trestle shoes, and weighed approximately 1,300 lbs. The transom was 12 ft. 6 in. span, 18 in. deep and 9 in. wide. It was built up of two lattice transoms, 2 in. by 18 in. by 12 ft. 6 in., set back to back, the ends of the transoms being riveted to the transom column housing and the intermediate portions of the separate transom members connected together by splice plates. The shoes consisted of flat steel plates reinforced with teeth at the corners to prevent side slipping. Their construction was such that the shoes could rest firmly on their foundations, and at the same time allow the side columns to stand in vertical positions.

Both types of trestles functioned equally satisfactorily under tests and successfully carried axle-loads up to and including 46,000 lbs. without excessive deflection or incident. The second type described is favoured because of its simplicity and relative ease of assembly. It is well to note here that a standard wooden trestle was used in the pontoon bridge constructed on land until it failed under an axle load of 13,500 lbs. The wooden shoe failed by splitting, allowing the unsupported leg to enter the ground a distance of 16 in., which in turn allowed the wooden cap to strike the ground with such force that the cap and three baulks were completely fractured. The incident showed the relative weakness of the standard wooden trestle.

Saddle Boat Support.

The tests indicated that the weakest bays are those adjacent to the saddle boat and trestles. An effort was made to eliminate the standard saddle and to adapt the long baulks for use in the bays adjacent to the saddle boat. The saddle boat was equipped with seven saddle transoms designed to secure a long firm bearing over the centre of the supporting boat, independent of any rise or fall in the water level resulting from rain or tides. Each saddle consisted of two wooden rockers constructed of oak, lying side by side and free to move independent of one another. The rockers supported their respective baulks across the entire width of the pontoon boat, the baulks being held in position by baulk-pins that engaged in baulk-pin sockets in their respective rockers. The rockers were housed in a steel cradle that extended across the gunwales of the boat. Under tests these saddle transoms did not function as expected, due to the fact that the saddle boat turned on its side in the water before the wooden rockers adjusted themselves to the gradient of the roadway. In view of the fact that the tests showed that an axle-load which could not develop the full capacity of adjacent boats would immerse the saddle boat to a 4-in. free-board, it appears advisable to construct the saddle support of two boats fastened together by lashings, with transom members lashed to the gunwales of both boats supporting a sill of the standard type now in use to carry the superstructure. It would also be advisable to reduce the length of the spans adjacent to the saddle boat.

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MISCELLANEOUS EQUIPMENT.

An abutment sill—shore transom—similar to the standard type and equipped with baulk pin sockets to engage the trestle baulks, 14 ft. hickory oars reinforced with special aluminium tips to prevent splitting, rowlocks adaptable to the higher free-board of the pontoons, and pickets constructed of standard galvanized wrought-iron pipe, were tested and found suitable for use with the new pontoon equipage.

TRANSPORTATION.

Studies of the requirements of modern armies in the field showed the desirability of having pontoon vehicles subject to being animal-drawn, truck-drawn or tractor-drawn.

The following extract from the historical record of the 464th Engineer Ponton Train indicates clearly the necessity of having pontoon vehicles constructed along automobile lines and capable of being truck-drawn :—

" On Oct. 29th we received an order to prepare to move overland to Bethelainville. Twenty trucks were provided to complete the movement overland of 67 vehicles, movement to be completed in one haul. As this was a physical impossibility we decided to comply with the order to the best of our ability. On Oct. 30th 19 motor trucks arrived and departed at 9.30 a.m. with 38 vehicles, each truck towing two vehicles. We were obliged to borrow 100 horses to bring the equipment from the Island to the main road, this work being done during the night of Oct. 29th under a bombing attack aimed at the adjacent steel plant. At 10 p.m., Oct. 31st, this convoy completed the movement to Bethelainville and at 4 p.m., Nov. 1st, the equipment was hidden in the forest. It would be well to note that we had advised very strongly against towing the pontoon equipment behind motor trucks, and this trip reduced the efficiency of the equipage about 50 per cent. All tongues were broken, braces twisted, bolts sheared and in some instances entire wagons overturned. On Oct. 31st, about 4 p.m., 15 French motor trucks arrived for the purpose of convoying the balance of the equipment to Bethelainville. Seventy-five horses were again borrowed from the ammunition train of the 92nd Division, and by working all night the 29 wagons were hauled up on to the main road and hooked in pairs ready for the trucks. At 5.20 a.m., Nov. 1st, all supplies, rations and office and equipment were loaded on the trucks at Pompey. The train then proceeded to Harbach where the wagons were lashed on and convoy started off at 8 a.m. The last truck reached Pierfeitte at 9 p.m. the same date; some motor trouble was experienced, but the greatest trouble was due to broken tongues and wheels on the pontoon wagons as those wagons were never made for this method of transportation. At 4.30 a.m., Nov. 3rd, four trucks (attached from 23rd Engineers) were started out with billeting detail, kitchen detail, all supplies and office equipment. At 5 a.m. Captain Goodwin left with 17 boat wagons drawn by four horses each, thus using all horses fit to work. It was found *en route* that four horses were not sufficient for handling the wagons over the rough and muddy roads encountered, and in many

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cases it was necessary to put 8 or 10 horses on a wagon to get through some of the bad spots. At 6 a.m. 18 of the promised trucks arrived and left with 18 wagons. At 1 p.m. same day all horses fit to move were sent forward on a moving picket line."

A pontoon wagon to transport the baulks and boats, a chess wagon to transport the chesses, and a trestle wagon for the trestle equipment, all capable of being drawn with equal facility by animals, tractor or truck, were designed, manufactured and tested. The wagons weighed approximately 2,400 lbs. each and were equipped with 40-in. rubber-tyred wheels, suitable pintles, lunette rings and draw-bars, and constructed in accordance with the general type of automobile design and practice. The wagons were reversible and capable of being turned or steered from either end when used as a single wagon or in trains of two wagons or more.

Tests of those wagons were conducted on the roads in and about the Camp. A horse-drawn test of 10 miles was made. The loaded pontoon trailers were drawn by six-line mule teams and the loaded chess and trestle trailers by four-line mule teams. On the whole the march was very satisfactory, the roller-bearing wheels reduced the friction so that the team pulled the greater loads with greater ease than the standard equipage. The route included several very steep grades, both up and down, ditches and several soft spots where the wheels cut in from 12 to 16 in. The day was warm and the mules came in sweated but showing no lather, and were apparently good for 10 miles more.

Various types of trucks, including the 1½-ton Garford, 3-ton Liberty and 5-ton Mack, were used to haul from one to three trailers over various types of roads, including concrete, gravel and dirt, at various speeds for distances up to and including 15 miles. These tests indicated that the 1½-ton Garford and 3-ton Liberty trucks were on the whole more successful for this work than the 5-ton Mack and that the lighter trucks were better for the poorer roads. More than two trailers should not be drawn by trucks except under very favourable conditions, when the truck may operate over a two-way road with little opposing traffic. The speed should not exceed 12 miles per hour. At higher speeds the trailers skidded away from the crown of the road towards the ditch, especially for speeds exceeding 15 miles per hour.

The Cadillac 2½-ton tractor, the 5-ton and 10-ton Holt tractors, were used to draw trains of one to five wagons. The vehicles tracked as well as could be expected. On narrow roads with a high crown the third wagon would often slide off the road into the ditch. On turning a train made up of two pontoon boat wagons and one chess wagon, drawn by a 5-ton Holt tractor, on a 60-ft. curve, the rear wheels of the third vehicle tracked 9 ft. inside the track of the front wheel of the first wagon. Trains of two or more wagons could not be backed in any desired direction. No more than three vehicles should be hauled by a tractor on a good road and not more than one on a poor narrow road. The stability of the load was increased materially when the pontoon boat was loaded on the wagon bottom-side up. In general the tests were severe and the wagons stood them well, but many weaknesses in

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the design developed which indicated that the trailers tested would not stand up under service conditions for a very long period. When the vehicles were drawn by animals, the brakes, which were of the automobile type, were applied over long periods of time, which caused them to overheat and wear rapidly. The rubber tyres wore out too rapidly, indicating the necessity for wider treads. The requirement of reversibility introduced many intricate features in the designs, requiring a two-point suspension similar to that of the Ford automobile, which obviously is inferior to a three or four-point suspension. It also necessitated a complicated brake mechanism which quickly became unserviceable. However, a direct-action brake precludes the use of rubber tyres which are considered essential for a truck-drawn vehicle. The springs proved to be too light. The radius rods proved to be weak and were badly bent when the pontoon boat wagon was mired in a mud hole and drawn therefrom. In general, all small parts such as steering-arms, brake-rods, tongues, pintle-hooks, chains, etc., were too lightly constructed, due to an effort made to develope a pontoon wagon trailer weighing less than 2,000 lbs., and would soon become unserviceable under severe service conditions. The superstructures of the various vehicles proved satisfactory.

In the Discussion Major C. P. Gross compared the following qualities as applied to the three boats :—Light weight, Non-sinkability, Minimum attention required, Ease of repair, Resistance to time and elements, Construction approximating boat lines, Rapidity of construction, Availability of material for construction, Immediate availability for service, Ease of loading and unloading, Ease of transporting, Behaviour under rifle fire, Ferrying capacity, Strength in bridge, Displacement capacity, and Cost, and found that in non-sinkability, ease of repair, behaviour under rifle fire, strength in the grounded bridge and in lower cost the superiority of the wooden pontoon is decisive. The wooden boat, however, is unsatisfactory when stored in a hot climate. The aluminium boat seems to offer relief in being at all times serviceable. Such serviceability is, however, more apparent than real. For instance, in unloading this equipment for test two holes were stove through the bottom of the metal boat, which required four hours for repair by welding with results none too good. In the field such repairs are not easily made and such condition would frequently invite abandonment. An undisputed merit of the aluminium boat is that for the same loading it has 2 in. higher free-board, and as a support, therefore, has a buoyancy greater by two tons than the wooden pontoon.

The equipment tested, with numerous minor modifications, does contain the elements of a bridge carrying the loads for which designed. All elements are not, however, properly balanced. The pontoon will support greater loads. The chesses, doubled, will not. No matter for what load intended, in the field the bridge will get all it can take. Chesses, $1\frac{1}{16}$ in. thick, belong to the old equipment. They have no real place in the new. This thickness should be increased to $2\frac{1}{2}$ or 3 in., one wagon carrying enough for one bay (double-chessed).

The placement of the trestle requires 16 men. The baulk is still a

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two-man load. The chess, even if 2½ in. thick, continues as a one-man load. The side rail section has a slightly easier task than formerly. A section of four men must be added to place the transverse baulks and baulk collars.

No satisfactory transportation has yet been developed. That tested failed beyond hope of recovery by simple modification. The requirements asked were far from simple, demanding construction not even commercial. The basis of military success is utter simplicity. It would seem apparent that to require a vehicle to be horse-drawn, motor-drawn and reversible must necessarily produce a hybrid. Reversibility is not essential. In a country of poor highways, the railroad rather than the motor truck should be used for the longer hauls. The vehicle must be horse-drawn. For controlled speeds it can be made capable of being tractor-drawn. Sure mobility, even though slow, is far more successful in campaign than bursts of speed separated by wild scrambles for spare parts.

Captain R. Whitaker gives further details of the tests. He mentions two more instructive cases of failure. In several cases when the train seemed to be about to stall, the men riding worked the brakes with such enthusiasm that the iron handles were completely broken off. During a test run over a concrete road the steel pole of a pontoon trailer broke and before the brakes could be applied the trailer ran off the road, smashing running gear and springs.

Major A. A. Keebler, E.O.R.C., thinks that rubber tyres are not essential. It is entirely practicable to construct a steel-tyred wheel which will maintain speeds up to 15 miles per hour, and the cushion for vehicle and load should properly be obtained by means of spring suspension. The outstanding requirement for a vehicle to be hauled by truck, tractor or animals interchangeably, is that it be mounted on a frictionless bearing such as balls or rollers, and it must be borne in mind that mounting a vehicle on ball or roller bearings does not particularly decrease the force required for traction. It will move much easier on level roads, but in ascending a grade the problem is one of foot-pounds.

NOTE BY R.E. BOARD.

In the light of our own recent investigations on this subject, as published in the *R.E.J.* for September, the following observations suggest themselves when considering the American principle of one large pontoon for all purposes in its possible application to our own requirements :—

(1) Whilst in our case it is necessary to provide for small wars, possibly in more or less hilly country, in which many of the rivers to be dealt with will be comparatively small, the Americans are no doubt basing their considerations on large wars in countries where rivers for the most part will be very much broader.

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(2) In the American organization no heavy pontoon equipment is to accompany the Division. It will remain with the Army and be allotted to Corps and Divisions as the situation may demand, the American intention apparently being to allot to the Division a light bridging train of canvas boats only (probably 185 ft. of bridge to each Division).

(3) For any given length of light bridge (*i.e.*, a bridge for the rapid passage of the fighting troops) the American equipment will require at least 50 per cent. more road space than ours. Thus, if the road space for our Divisional Bridging Train is to be restricted to the present limit, the length of Divisional bridge possible with the American form of equipment would be less than 130 ft.

(4) The length of the American pontoon waggon loaded (32 ft.) is likely to be too cumbersome for the conditions of road traffic which may be expected during operations.

(5) It is claimed that the 32 ft. American pontoon can be easily handled by a party of from 18 to 20 men. It seems very doubtful if this would be the case when the pontoon has to be rapidly off-loaded and handled under fire for the formation of " Light Bridge " for the passage of the fighting troops of the Division. The wooden pontoon, which seems on the whole to be the type most favoured in the report, would mean a load of 110 lbs. per man for a 20-man detachment, whilst the *lightest* American type projected (aluminium) would give a load of 80 lbs. per man, which latter load we consider as the extreme limit allowable.

The method of loading proposed for the American pontoon (upside down) does not appear conducive to ease and rapidity of off-loading for a boat of that length, and in fact the pontoon seems to have been rather damaged in the process of off-loading.

(6) A bridge of single pontoon piers of the American form will take an 8-ton rear-axle load (equivalent approximately to our commercial lorry) *singly*, but probably not in a string, whilst the means of providing for any greater loads than this does not seem to have been considered. The necessity for *doubling* the first boat piers at the shore ends which is suggested in order to obtain the required free-board under the above load, detracts somewhat from simplicity and expediency of construction.

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(7) Strength to resist crushing when grounded is considered by the Americans as well as by ourselves to be an important requirement. The only American type, however, which appears to have withstood this test satisfactorily was the wooden one, and the *weight* of the latter (2,250 lbs.) would seem to preclude its suitability for "light bridge," as pointed out in (3) above.

(8) The road bearers, which consist of 7 heavy wooden baulks, 2 steel rails and a transverse transom, do not seem to lend themselves to the rapid construction of "light bridge," for which they are, moreover, unnecessarily strong.

(9) The American design is for gunwale loading. Our investigations have led us to the conclusion that this method is neither so sound in theory nor so efficient in operation as saddle loading.

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REVIEWS.

AEROPLANE PERFORMANCE CALCULATIONS.

By HARRIS BOOTH, B.A., A.M.I.C.E. (Chapman & Hall. 21/-).

This is a highly technical treatise and should be very valuable to engineers interested in the design of aeroplanes. By the term "performance" is meant the numerical evaluation of everything a machine can do under assigned conditions as to weight, engine power, etc. The book is more than a mere theoretical treatise; very full and clear explanations are given how to work out the very intricate calculations necessitated in aeroplane design. J.M.W.

ENTROPY AS A TANGIBLE CONCEPTION.

By ENGINEER-COMMANDER S. G. WHEELER, R.N. (Crosby Lockwood. 8/6.)

Entropy has been defined by a prominent physicist as the "Logarithm of the Probability of a State," which, though not altogether a bad definition, conveys little to the tyro. In this modest little treatise, after a clear exposition of "Thermal Inertia," the subject of temperature charts is introduced, the final objective being the elucidation of "added heat," and "adabiasis," and it appears that Entropy may be regarded as the degree of adabiasis. It is, of course, impossible to convey in a few lines what entropy really is, and anyone wishing to grasp this point cannot do better than consult this treatise. Mathematical investigations have been avoided and the subject has been presented in such a way that little mathematical knowledge is required for an understanding of the text. J.M.W.

MEX FUEL OIL.

(George Philip & Son. 10/6.)

A copy of the second edition of this book, full of interesting details of oil engines and machinery, with many explanatory illustrations, has been presented to the R.E. Library by the Anglo-Mexican Petroleum Company, Ltd., 16, Finsbury Circus, E.C.2. F.E.G.S.

THE CHRONICLES OF A GAY GORDON.

By BRIG.-GENERAL J. M. GORDON, C.B. (Cassell & Co. 10/6).

There is not much gaiety in this book, but it is a very readable account of the strenuous career of a nineteenth-century soldier of fortune, half Spaniard, half Highlander, which began at the Shop in 1873 and ended in the appointment of Chief of the General Staff in Australia just before the outbreak of the Great War. The advice given him by his relative, General Charles George Gordon, deserves quotation—"Never allow your pleasure to interfere with your duty." The description given in Part III., Chapter 3, of the introduction of Universal Service in Australia is especially interesting. F.E.G.S.

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NOTICES OF MAGAZINES.

MILITÄR WOCHENBLATT.

No. 14.—"*Technique in the War of the Future.*"—The writer points out how the never-ceasing effort to concentrate great power within a small compass has led to great, and will in the future lead to still greater, development of mechanical weapons. He does not agree with the idea, which seems to die very hard in the German Army, that skilful and determined infantry can cope with tanks, and foresees great possibilities for this weapon. The apparent emptiness of the battlefield, which was becoming such a feature of the later stages of the war, will be still more accentuated and attack and defence will assume ever-increasing depth.

For the personnel of the battle of the future, he says discipline will more than ever be necessary, but it will not be the mass-discipline of the past; rather will it be that of the single-handed machine-gunner who forces himself, while under the heaviest barrage fire, to correct a stoppage in his gun. The more the individual has to fight on his own, the more independence must he have; and the finer his weapons the more self-control and technical skill will he require. Instead of the former hot-blooded thrusting onwards, the fighting man will have to show cool and calculating determination, and the victory of the future will belong to the army which disposes of a highly developed material and a personnel physically and technically competent to use it, and mentally and morally equal to the strain which its use will entail.

The West Hungarian Crisis.—An Austrian correspondent, who contributes an article on the Burgenland crisis, thinks that the collisions between the Austrian troops and the Hungarians will have ultimately a good effect on the former. Their weakness in equipment and material, due not only to the action of the Entente, but also to the criminal wastage of army property which went on unchecked during demobilisation, has been brought home to the Austrian people in forcible form. The writer expresses the hope that the latter will now appreciate the necessity for a well-disciplined, non-political and well-equipped force, and that the weaknesses of the Austrian Defence Force, in these respects, will now be made good.

No. 15.—"*Who caused the War?*" General von Zwehl brings up this question once more and trots out all the old one-sided arguments to prove that Germany is innocent. England's fear of the ever-stronger German Fleet, Russia's longing for Constantinople and France's lust for revenge made these three plan the world war, for which the Austrian adventure on Serbia offered a welcome opportunity. Needless to say that Belgium is not mentioned, and no incriminating dates regarding German, nor any Austrian action.

General von Zwehl says it is necessary to peg away at this question of Germany's guilt, because the Versailles Treaty is founded on it, and until it is disproved and her innocence accepted, no amendment of the treaty can be hoped for.

"*Officer-baiting.*"—The *M.W.B.* deplores the fact that this is still

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carried on in many papers, and that efforts are now being made to raise ill-feeling between officers of the "noble" and "bourgeois" classes. These efforts naturally take the form of gross abuse of the former, but it is curious that their personal courage should be so much attacked. "Telephone-generals" is a nice form of reproach; "'Noble' is synonymous with 'Candidate for an appointment on the L. of C.'" is another.

"*Wearing of Uniform.*"—The regulations governing the wearing of uniform by demobilised and retired officers have been modified to some extent, in spite of some rather coarse cartoons in the *Lustige Blätter*, and uniform may be worn on certain specified non-political occasions; special badges of unions and associations are forbidden.

No. 16.—*Leadership.*—General von Freytag Loringhoven has tried to analyse the qualities which must be united in a leader before he can expect to be accepted by history as one of the great generals of the world. Starting with Alexander, Cæsar and Hannibal, he depicts Napoleon, Gneisenau, Blücher, Wellington and Lee and associated with them Hindenburg, Ludendorff and, curiously enough, Falkenhayn and Hotzendorff. Although success may not necessarily be the test of greatness, it seems as if the last two were included chiefly with the idea of swelling the Teutonic ranks. The *M.W.B.* welcomes the book and hopes that the more Germany may be disarmed materially, the more she will steel her heart and arm her soul with patience.

The Campaign of the 9th (German) Army against the Roumanians and Russians.—General von Falkenhayn has published the second part of his book. He appears to have suffered from interference both by G.H.Q. and the Austrians, under whom he was at one time placed, but in spite of this his army must have done very fine work. In ten days the cavalry corps under von Schmettow, supported by Kuhne's group of divisions marched and fought over 200 kilometres of bad mountainous roads in the depth of winter. At a critical moment, when Mackensen's group was in danger of being attacked in rear, a Bavarian battalion captured a copy of the Roumanian orders, the situation was met just in time, and the Roumanian army was destroyed. The bulk of the Germans covered a daily average of 9 miles for a period of 26 days, which, under the conditions described, must have been a great performance. Taking together the size of the forces on both sides, the variety of the country fought over, and the very mobile nature of the campaign, it should provide material for many generations of military students.

The situation in the Far East.—The *M.W.B.* has news of events in Eastern Siberia, which is definite, if not necessarily accurate. Semenoff is said to have been disappointed in his hopes of Japanese support, and let down by treachery among his own people. After the Kappel troops mutinied in Vladivostock, Semenoff led his own formations to the Ussuri district, but the Japanese declared that they would not interfere in the private affairs of the Far East Republic, (having seen, says the *M.W.B.*, that Semenoff's star was waning) disarmed many of the White troops, and seized all the funds they had deposited in Japanese banks.

Semenoff had no choice but to resign, advising his successor to adhere to Mirkuloff, a social-democrat, who had meanwhile gained the upper hand in Vladivostock. It was, however, too late and the Bolsheviks gained control of the latter place and instituted a thorough "Terror."

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It appears as doubtful as ever if the Japanese can really tell which horse to back, as some of Semenoff's troops may re-organize in Manchuria and the complete collapse of the Whites is still by no means certain. The latest news credits them with substantial successes near Irkutsk and Petrovsk, and at the former place the entire 33rd Red Division is said to have gone over to them.

No. 17.—"*The prospects of an Officer in the Reichswehr.*"—Many parents, particularly widows of old army officers, have been asking for advice before putting their sons into the Reichswehr. The *M.W.B.* thinks that the admitted difficulties of present conditions should not deter young men of good families from a military career. The first four years, which must be served in the ranks, will be hard, but the tone of the army is good and the mixture of classes that is being effected is likely to have good results. From a national point of view it is hoped that the "Noble" classes will not hold back.

L. CHENEVIX-TRENCH, *Major, R.E.*

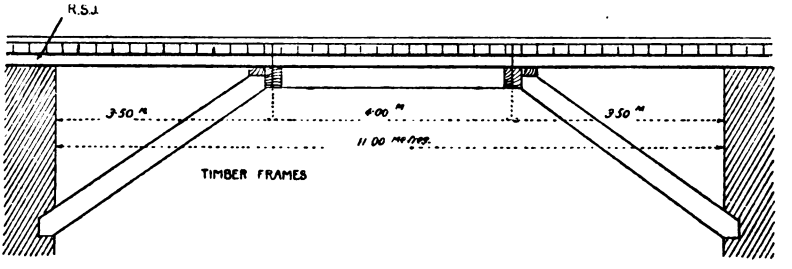
REVUE DU GÉNIE MILITAIRE.

May, 1921.

An article on the crossing of the Lys and the Escaut by the French Army in Belgium.—By CAPTAINS SOUBRET and GEX.

This article is divided into two parts (1), a historical summary, and (2) a technical survey of the methods employed.

The bridges were required to take heavy traffic, up to 20 tons total load, and, it not being possible to bring up materials from the rear, had to be constructed of stores found locally. For spans up to 20 ft. rolled steel I joists, up to 7 in. in height, were used, braced together at one or two points along this length. From 20 ft. to 60 ft., steel joists



strengthened as shown in attached sketch were used. Corbelling was extensively used to reduce the clear span. These bridges were found to be much lighter and much quicker to erect than pile bridges.

Measuring the width of a river.—By MAJOR TRICAUD.

The author points out that the margin of error in ascertaining the width of a river by field methods is very large and analyses this error compared to probable errors in the measurement of distances and angles. He comes to the conclusion that the greatest accuracy is obtained when the base is approximately 1·2 × the width, and one of the angles at the base is a right angle. He gives a table for the value of e with various methods of measuring such that the error in measurement of the width lies between $(1 + e)$ times the width and $(1 - e)$ times the width. In this table e varies between ·0110 and ·215.

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June, 1921.

The Evolution of the French Defensive Doctrine.—The author, Colonel Normand, of the 12th Regiment of Engineers, traces the evolution of the French system of defence between 1914 and 1918, as necessitated by the ever-changing conditions of modern warfare, and summarizes his article in the table given below :—

August, 1914.	
Rifle fire predominant. Light and heavy field guns. Machine Guns.	Linear organization ; soldiers elbow to elbow. Disconnected trenches. Light shelters.
November, 1914.	
Stabilization. Fortification has the upper hand of artillery. Positions instead of trenches.	Three successive continuous trenches (Supervision, principal and reserve). The first line is the line of resistance. Machine guns in the front line. Short communication trenches. Loop holes and covered trenches. Shelters covered with three layers of pit props, separated from the trenches. Curved iron sheets. Telephones.
June, 1915.	
Grenades. Trench artillery. Balloon and aeroplane observation. Close contact with the enemy. Very lights. Searchlights.	Centres of resistance. Passive intervals, believed impregnable, covered by flanking fire. Decrease of personnel in the front line. Listening posts in the wire. Infantry arranged in depth. Small mined and concrete shelters. Obstacles wider, at least two layers. Netting on the parapets, against grenades. Mines. Improvement in camouflage. Artillery barrages. Casemated batteries near the front line. Flanking guns. A second position three or four kilometres behind.
December, 1915.	
Development of heavy artillery. Minenwerfer. Gas. Flame throwers.	Continuous lines with intervals lightly held ; *points d'appui* surrounded by obstacles and grouped into centres of resistance. Reverse slope positions. Support trenches. Machine guns in the open, echelonned in depth, Short field of fire, but artillery O.P.'s with long observation, sometimes armoured, and well camouflaged. Sectors. Main C.T.'s organized for defence. A second strong position six or eight kilometres behind. Intermediate positions. Immediate counter-attack. Bomb-proofs ; metal shields ; portable O.P.'s. To do the greatest possible amount of damage to the enemy.

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August, 1916.	
Artillery development. Abundance of munitions. Gas. Flammenwerfer. Automatic rifles; rifle grenades V.B. Improved portable tools (France).	Centres of resistance joined by trenches; *points d'appui* hidden by the same. Alarm posts. Immediate counter-attack to regain lost trenches. Cover as far as compatible with observation and fighting. Armour. A second position six to eight kilometres behind. Artillery defence line. Artillery echelonned in depth. Counter-preparation fire. Barrage fire. Communication (visual, pigeons. etc.,)
March, 1917.	
Gas.	Material rather than personnel in the front line. Machine guns and automatic rifles echelonned in depth outside the trenches. The principal rôle of infantry is movement.
August, 1917.	
Aerial photography. Artillery overwhelms defences. France: 37 mm. guns.	Dispersion of fortification. Automatic arms separated and concealed. *Groupes de combat* connected laterally and from front to rear. Numerous underground galleries. Switch lines. Artillery counter-preparation. Concentration of fire. Grouping of machine guns for indirect fire.
December, 1917.	
France: very powerful, heavy artillery. Anti-aircraft artillery. Tanks. Offensive aviation. Stokes Mortars.	Active defence; troops in echelon for immediate counter-attack or deliberate counter-offensive. The garrisons fight on the first position, but the possibility of the decisive battle being fought on the second position is realized. Defence plans. Reinforcing plans. Multiplied methods of communication, *e.g.*, wireless. Organization of artillery into Divisional, Corps and Army, with separate rôles and calibres. Batteries distributed in depth. Second positions pressed on.
April, 1918.	
Numerous German reserves. Very powerful artillery of all kinds. The gun is stronger than fortification.	Resistance in depth, without retreat; *Groupes de combat* staggered. Active zones and passive zones. Everyone must fight to the end wherever he may be.

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June, 1918.

Massed tanks. Smoke screens. Numerical superiority of the Allies.	Limited withdrawal; a position of resistance (three-quarters of the effectives) on which the enemy is to be brought to battle; covered by advanced posts. A back position to arrest an enemy advance, occupied by elements of Army Troops. Manœuvring to regain lost ground; definite objectives for counter-attack, supported by fire. Artillery behind the line of resistance; batteries echelonned in depth and organized for defence.

Bridges made from barges from the Ourcq Canal.—By CAPT. NETTER.

The problem of bridging the Rhine presented difficulties and the possibility of using the above barges was suggested. The barges were 28·5 m. long, 3·05 m. wide, 1·28 m. high at their centres, weighed 20 to 22 tons empty with a displacement of 75 tons. 275 of these existed in 1914, of which 250 were of steel. It was found that each barge could be carried on five railway trucks and could then pass through tunnels, under bridges, etc. Three roadways were used, the centre one with road bearers of wood for troops, light motor vehicles, etc., the two outer ones for the heaviest traffic, with steel I girders as road bearers. A bridge of 200 metres length was tried on the Rhone and proved a complete success. Two such bridges of 500 metres were formed and kept in readiness for use if required.

C. LA T. T. JONES, *Captain, R.E.*

REVUE MILITAIRE GÉNÉRALE.

September, 1921.

Great Britain and Russia.—By MAJOR A. GRASSET. The rivalry of Great Britain and Russia has continued for some three centuries, and has at times influenced the policy of the whole civilized world. If its incidents are complex, its aims are simple, *i.e.*, Russia's efforts to secure an ice-free port, and Great Britain's efforts to frustrate her. By founding his new capital on the Baltic Sea, Peter the Great forced on England, in 1801, a naval occupation of Copenhagen at the risk of alienating the Danes, and on Russia's endeavours to secure access to and from the Black Sea hinged the whole "Eastern Question." In 1854 Britain found an ally in France, and the costly Russian fortifications at Sebastopol, and at Petropavlovsk on the Pacific, were overthrown. The same nations prevented Russia from obtaining a port in Ofoten Bay on the Norwegian coast.

In 1856 Russia obtained from China the maritime province of the Amur, and founded Vladivostock, but this port is closed by ice for three months each year. In 1877 Russia made a direct attack towards Constantinople, and when signing the Treaty of San Stefano, thought that her dream was at last realized, since she obtained a wide front

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on the Mediterranean through her allies Roumania and Bulgaria, but Great Britain at the Treaty of Berlin was instrumental in creating the state of Eastern Rumelia, thus cutting off Russia from that sphere of influence, and by occupying Cyprus kept watch on Russian designs in Syria.

Russia now turned to the East, quietly advancing on the one hand through Persia, on the other through China, each step marked by the advance of her railways and by settlements of Cossacks along the line, who made friends with the indigenous inhabitants. Thus grew the line from Azun Ada on the Caspian (joined to Baku by a steamer service) through Merv and Samarkand to Tashkent, while projects were on foot to join the last-named by rail with Omsk and Orenberg on the Trans-Siberian line. A secret treaty with Persia gave the Russians leave to construct a line from Tauris to Bunder Abbas on the Persian Gulf, and even to lease that port as a base on the Indian Ocean. By 1901 the Trans-Siberian line, 8,000 miles long and built in ten years, connected Vladivostock with Orenberg. Since 1894 Russian influence had been extended into Mongolia, Manchuria, and Corea, but in these regions a new adversary, Japan, was met.

After the Chino-Japanese War Russian intervention deprived Japan of the best fruits of her victory, and all the great powers scrambled for concessions in China, Germany obtaining the Bay of Kiao-Chao, England Wei-hai-wei, while Russia consolidated her hold on Ta-lien-wan and Port Arthur, thus at last realizing the dream of Peter the Great. Russia's correct attitude to the South of the Great Wall during the Boxer Rebellion secured for her the everlasting gratitude of the Chinese, while the discourtesy of the British and Germans was repaid by hatred, and the moderation of the French by tolerance. To the north of the Great Wall Russia acted alone; diplomacy was out of place, there was only revolt to be broken, and this General Grodekoff's army accomplished thoroughly, occupying without firing a shot the whole of Manchuria, the coasts of which are open to the ocean. The Trans-Siberian railway was at once extended from Vladivostock to Stretinsk, and a branch from Kharbin laid to Port Arthur. With the connivance of Li-hung-chang a Russo-Chinese Bank was opened at Urga in Mongolia and a Trans-Mongolian railway projected to connect Kailar on the Trans-Siberian with Kalgan on the high road from Peking to Kiatkha. To protect this line Cossacks at once swarmed into Mongolia and fortified a post at the entrance to the Sewantze Pass, within 100 kilometres of Peking. Scientific and religious missions penetrated into Zungaria and Thibet, and an alliance was concluded with the Dalai Lama, fore-runner of a protectorate.

Great Britain was on the watch, but relations with Persia and Thibet were unfortunate. The military occupation of Sikkim threw Thibet into the hands of Russia, while the dispatch of a fleet for a cruise in the Persian Gulf alienated the Shah. On the Japanese side her policy was more successful, and affairs in Corea soon drew Russian attention away from India. With the aid of funds from England an anti-Russian Society, the "Tairo Dashikwai" was founded, which united almost all the influential men in Japan, dominated the Chamber, and, in spite of

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the opposition of the Mikado, and his Prime Minister, Count Katsura, impelled the Empire to direct action. On various pretexts war was declared, Russia was defeated and driven from the extreme East. About this time British statesmen began to wonder if their policy of trying to withstand the irresistible tide of Russian expansion was not a mistake. Arrested everywhere else, that tide must flow towards India, where England, far from her base of supplies, and threatened also by internal dissensions, stood alone to oppose it, but Russia had wounds to heal, her forces to reorganize, the Austro-German frontier to guard, and before she could pull herself together the great war of 1914 broke out.

In this war Russia has been defeated, her army destroyed, her throne uprooted, and the nation is plunged in anarchy. But her dream of the sea is not ended, and, denied the far East by Japan and China, has turned to the Middle East, where the division of the Ottoman Empire between the governments of Constantinople and Angora opens a new vista. The precepts of the Koran are against revolutionaries, still help is required against Greece assisted by England, and joining hands with Lenin does not imply that the embrace need be more intimate. An agreement between Angora and Moscow was signed on 16th March, 1921, by which the latter guaranteed the integrity of Turkey, accepted the internationalization of the shores of the Black Sea and of the Straits, and subscribed to the abolition of the capitulations. Not content with this victory, the Soviet Government instigated an agreement between Angora and Afghanistan proclaiming the principles of self-government, and mutual material and moral support in case of an attack on either by a third party. Afghanistan recognized the religious supremacy of the Sultan, and a Turkish military mission was to reorganize the Afghan army. In spite of this alliance, and probably because Angora has not invoked it, Russia has remained inactive during the duel in Asia Minor, still her armies are massed on the frontier ready in case of a Turkish defeat, and only the future can show whether British diplomacy is right in supporting King Constantine and forcing the Turks into the arms of the Bolsheviks.

In Persia the struggle between Russia and Great Britain is equally severe. Conscious that Persian opinion was against her, Great Britain renounced the Anglo-Persian agreement of 1919 and withdrew her troops, retaining only the administration of the finances, as other nations control the other public services. The Soviet countered by renouncing all the privileges granted to the Czar, cancelling the Persian debt to Russia, and restoring the territories ceded in 1893, thus assuring themselves of Persian goodwill. In return the government of Teheran permits Russia to send troops into the country if Persia is attacked by any foreign state. On 24th of last May a cabinet still more jealous of national independence was formed in Persia, which, although not revoking the accord with Russia, lost no time in dismissing the English financial advisers, and withdrawing the concessions granted to the Persian Transport Company.

Only one state now separates India from the red flood, and that is Afghanistan. Since 1920 a British Mission under Col. Dobbs, and a Russian one under M. Suritz have been in Cabul. The former at first obtained an agreement which formally guaranteed the political and terri-

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torial integrity of Afghanistan, but bound the Amir to forbid anti-English propaganda, to receive no subsidy from Moscow, and not to allow any Russian agent near the Indian frontiers. This agreement lasted no time at all, and on 25th February a formal treaty placed Afghanistan in dependence on Russia, the latter to pay the Amir a million roubles and to furnish experts for laying a telegraph line from Herat to Cabul. Russian consulates were to be established on the Afghan-Indian frontier, and Afghan consulates in the great towns of Russia. Great Britain was only saved by famine and pestilence in Russia; M. Suvitz was recalled, and Col. Dobbs hastened to recover his lost ground. Warned of the false promises of Moscow, and persuaded of the waning power of the Soviet, the Amir, in spite of his secret preferences and the treaty binding him to Augora, signed a treaty with Great Britain which binds him to break off relations with Russia and accept an English subsidy; but, cautious to the end, he exacted delay in the execution of the treaty until the British General Staff shall have organized a strong line of resistance along the Russo-Afghan frontier, and stocked the country with food, arms and munitions.

Just in time India is saved, for besides communistic ideas, Lenin's emissaries are adepts in political and religious propaganda, potent weapons in the East. At the same time Britain's concession to the Indian races of a share in the conduct of government in consideration of their sacrifices for her in the war have not been appreciated at their proper value, and the electors have returned to the Councils a majority of irreconcilables with whom cool discussion of national defence will be difficult. Last March at Delhi a large reduction in the army was demanded, and in spite of strong opposition from the C. in C. the government had to yield. The army in India has consequently been reduced, and, although the equipment of machine guns, tanks, air-craft and armoured motor cars has been increased, it will not compensate for the reduction of effectives, nor for the moral effect produced by this defeat of British authority. The horrors brought on Russia by the regime of Lenin and Trotzky are such that they cannot be prolonged, and when they pass the need for access to the open sea will again make itself felt, and history will resume its course.

The Revision of the Regulations.—A continuation of the article by Lucius. Fourth period, *i.e.*, the German attack on Verdun (21st February to 11th July, 1916) and the Franco-British offensive on the Somme (1st July to end November, 1916) and in Artois and on the Aisne (9th April to 15th May, 1917).

The new conceptions of the attack evolved from the operations of 1915 were issued in 1916 in three sets of Instructions dated 16th, 26th and 8th January. Since the artillery cannot from its original position simultaneously prepare two enemy positions for attack, the Instruction of 16th January laid down that attacks must be successive, and to capture each position at least part of the guns may have to be moved up. Having captured the immediate objective, troops at once reconnoitre the next, and select observation posts. To reduce the period between successive attacks commanders must have already organized the next attack and try to launch it before the enemy has had time to recover. When all

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the positions have been taken, the cavalry will act as directed in the Annexe of 18th June, 1915, and its commander must during the infantry attack be well up, generally in the command post of a first line infantry division. This Instruction also established the separation of the two duties of observation and communication, a considerable progress; that of 26th January divides the attack into two phases, the first comprising the organization of the position, the second commencing with the arrival of the fighting troops. Before the attack of each position, plans must be prepared and issued, showing the employment of every unit, artillery plan, works plan, supply and evacuation plan, communications plan. The employment of the larger formations is definitely regulated; the corps will consist of four or five divisions, the front of attack to be of the width of two divisions; strong reserves are to be ready to replenish the attack. The division is the combat unit, its commander co-ordinates infantry and artillery action and assures their supplies; the corps is the attack unit, its commander decides the plan of battle, the direction of the attack, controls the reserves, and is responsible for exploiting the victory. The army co-ordinates the action of the corps, and sees that the pursuit is rapid and thorough. The conditions of success are good order, and artillery support for the infantry. Units in first line are to be relieved before they become exhausted. The Instruction of 8th January defines anew the attributes of infantry. It has no power against obstacles—men do not fight material; it has great potentiality for occupying ground, is rapidly expended in action, must not manœuvre in dense formations, and its *morale* is extremely sensitive. Henceforth infantry will be replaced to a great extent by gun, machine gun, and automatic rifles. All artillery employed in destruction is to be under the divisional general, a great proportion of it will be pushed as far as possible to the front, and change of position during action is to be restrained to the utmost.

The three Instructions refer to trench warfare only, and, enjoining more method and order in the attack, involve some delays. In regular siege warfare where the enemy is invested time is of less importance, but under the conditions of the Great War, where he can bring up reinforcements, the period of delay between successive attacks is incompatible with the order to attack him before he can recover, and stratgeic surprise is impossible. The plans referred to above had to be approved by higher authority up to the Army in some cases, and this excessive centralization is to become more and more marked to the detriment of the initiative and responsibility so necessary in open warfare, such as the period of exploitation of the success. Although the employment of cavalry to exploit the success is prescribed, the action of the larger formations is only vaguely touched on. In the case of a partial success a warning is given not to push too far ahead partly disorganized troops, but it is also laid down that favourable opportunities must not be lost owing to undue timidity. To compel infantry not to go beyond a certain point fixed on a plan beforehand is to deny them the full use of their success.

All commanders, and especially Divisional Generals must cultivate the *morale* of their troops, and the first quality to develop is energy. —(*To be continued*).

A. R. REYNOLDS.

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REVUE MILITAIRE SUISSE.

No. 6—*June*, 1921.

The Psychology of War.—The *Revue* article is a translation from the German text of a memoir by Dr. A. L. Vischer on the above subject. This memoir appeared originally in the *Allgemeine Schweizerische Militärzeitung*, and is a lucid presentment of a most important subject. Dr. Vischer points out that the decisive elements which make for victory in war lie not alone either in the armament or in the equipment of the opposing forces; the psychological faculties of the soldier, as an individual as well as a member of a group, have also to be reckoned with. For some years past, a number of scientists have devoted themselves to research work in relation to the mental capacities of men, and have framed suitable physiological and psychological tests with a view to grading them according to their aptitude for various callings and professions. The Americans, as is well known, made considerable use of examinations of this kind in connection with the selection of men for the different branches of the Army raised in the United States for the Great War; they express themselves well satisfied with the results thereby obtained. Much interesting and valuable information is contained in the original article upon the mental attitude of soldiers during the Great War. Uncertainty as to the future had, on account of the unexpectedly long duration of the campaign, a most demoralizing effect upon them in some cases, and gave birth to a carping spirit. The tendency which existed, at one time, for those in the ranks to magnify their grievances, and see alone the weaknesses in their superiors was fraught with grave mischief. Dr. Vischer remarks that General Pétain showed true insight and a just appreciation of the psychological necessities of the moment when, on June 2nd, 1917, he issued his circular, containing the simple and precise statement regulating matters connected with leave of absence, rest, rations, &c.; the wide dissemination of the information therein contained did much to clear the atmosphere and definitely to remove the disturbing influences which were sapping the *morale* of the French Army and bringing disastrous consequences in their train. The original article is most instructive and deserves to be widely read.

NOTES AND NEWS.—*France.*—A special correspondent draws attention to the fact that the text of the proposed new Law relating to the French Army has been recently published: the draft Law is intended to take the place of the basic Law of March 13th, 1875. The draft Law is divided into four chapters: in the first chapter is set out the composition of the French Army as proposed—apparently it is intended that the Division shall be the highest peace time formation permanently to be maintained; in the second chapter are given the units of the various arms, infantry, cavalry, artillery, engineers and air force—many details in relation to the various branches of the service are reproduced in the *Revue*, and it is interesting to note that, as compared with 1912, reductions are proposed in the infantry (from 173 to 162 regiments) and in the cavalry (from 89 to 67 regiments), on the other hand, increases are proposed in the artillery (from 75 to 93 regiments) and in the engineers (from 7 to

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15 regiments), at the same time the air force is to be increased from 3 groups to 21 regiments; in the third chapter are given the establishments of the Corps of officers—*inter alia*, an establishment of six Engineer Generals, 1st Class, and 18 Engineer Generals, 2nd Class, is provided in connection with manufactures and military works; in the fourth chapter are given the establishments of the "staffs" and of the "special services."

United States of America.—A special correspondent writes that General Pershing has, in the new post created for him at the G.H.Q. of the American Army, been entrusted with the preparation of a co-ordination scheme in relation to the National Guard, the Reserve formations and the Regular Army, with a view to enabling the United States to put into the field a force of a million men in the event of a mobilization for war purposes. Attention is also called to the arrangements which are being made to provide instruction, non-military in character, at the Dix Camp, New Jersey, for officers and non-commissioned officers in order to enable them to acquire knowledge on subjects likely to be useful to them in civil life. It is expected that by the end of October of the current year there will be assembled at the Camp some 9,000 to 10,000 men, divided into about 100 classes (54 academic and 57 professional), under 200 instructors. The Dix Camp is one of the largest and most elaborate of the encampments constructed during the Great War: it is now the headquarters of a division of the 2nd Corps and also the summer camp of the West Point cadets.

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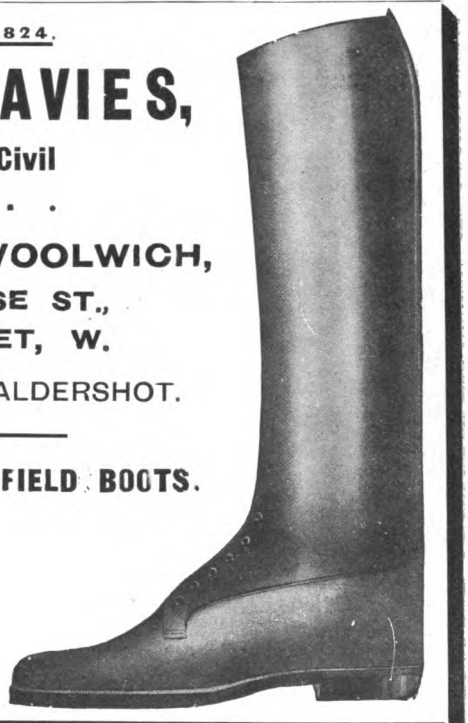

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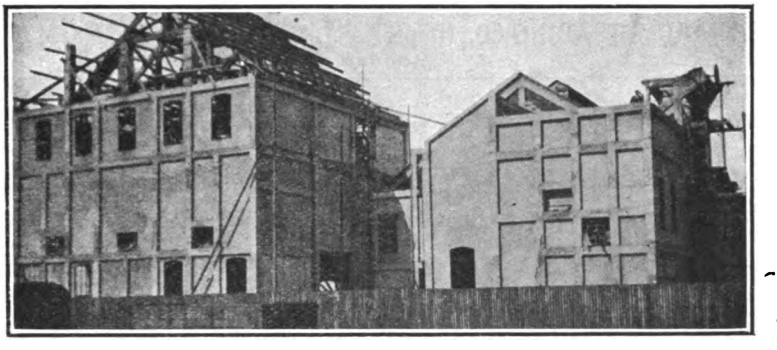

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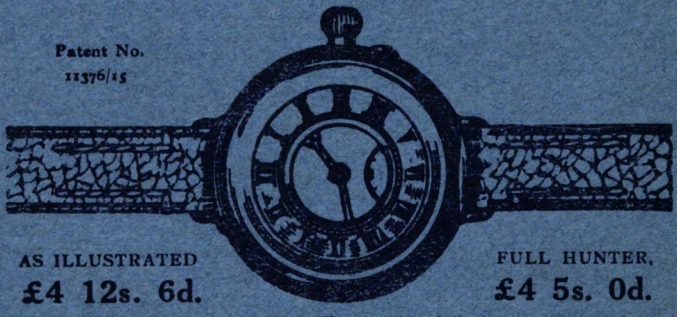

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